PLANNING FOR LOW DENSITY — A SOLAR APPROACH

PLANNING AND DEVELOPMENT DEPARTMENT REGIONAL MUNICIPALITY OF HAMILTON-WENTWORTH CITY HALL HAMILTON ONTARIO CANADA L8N 3T4

SINCE THE SUBJECT OF THIS REPORT IS ENORMOUSLY WIDE AND COMPLEX, INEVITABLY THE TREATMENT OF SOME PROBLEMS MIGHT BE UNEVEN AND PERHAPS SUPERFICIAL. IN ADDITION, WE DO NOT WISH TO PRETEND THAT THE WHOLE IS ORIGINAL SINCE IN MANY PARTICULAR AREAS WE HAD TO RELY ON A NUMBER OF OUTSIDE SOURCES WHICH EXAMINED AND DISCUSSED INDIVIDUAL PROBLEMS MORE EXPERTLY THAN WE COULD HAVE DONE. SOME ORIGINALITY MIGHT BE FOUND IN THE WAY THE VAST AMOUNT OF DATA WAS COMPILED, DIGESTED AND TRANSPORTED INTO RELATIVELY SIMPLE, USEFUL TOOLS FOR EVERYDAY USE.

OUR IDENBTEDNESS TO MANY PUBLISHED SOURCES IS OBVIOUS FROM THE SIZE OF THE BIBLIOGRAPHY.

MANY AGENCIES AND INSTITUTIONS ASSISTED US BY KINDLY PROVIDING US WITH ENVIRONMENTAL DATA AND OTHER INFORMATION.

WE ARE PARTICULARLY THANKFUL TO THE FOLLOWING:

ENVIRONMENT CANADA, ATMOSPHERIC ENVIRONMENT.

HAMILTON AIRPORT, MOUNT HOPE, ONTARIO.

CANADIAN CLIMATE CENTRE, DOWNSVIEW, ONTARIO.

ROYAL BOTANICAL GARDENS, WEATHER OFFICE.

ACKNOWLEDGEMENTS

This is the third report on energy conservation produced by the Planning Department of the Hamilton-Wentworth Region. The two previous reports were:

- Energy Consideration in Urban and Regional Planning (January, 1978); and,
- Opportunities for Energy Savings in High-Density Urban Developments (August, 1979).

NOTE

- To assist planners and to improve subdivision design;
- To assist design professionals, developers and home builders in preparation of development proposals; and,
- Arouse general awareness of the link between lifestyle and energy consumption.

PURPOSE OF THE REPORT

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ONCE UPON A TIME, A HANDFUL OF INDIVIDUALS HAD THE "CHUTZPAH" TO SAY THAT ENERGY IS SUPPOSED TO BE SAVED AND NOT WASTED, THAT WE SHOULD BUILD OUR HOMES AND COMMUNITIES IN A DIFFERENT MANNER, AND THAT OUR LIFESTYLE SHOULD BE CHANGED.

THEY WERE IGNORED.

LATER, MORE RESPECTABLE AND LARGER GROUPS SAID THE SAME. THE REACTION WAS A MIXTURE OF AMUSEMENT AND DISBELIEF...

THOSE DAYS ARE OVER. THE LAUGHTER HAS DIED.

THE MATTER IS NOW A DEADLY SERIOUS ONE.

PREFACE

In case a true energy shortage occurs, the subdivision dweller is potentially the most vulnerable. It requires enormous amounts of various types of energies to support our present suburban land use arrangement. The cost of these energies is slowly reaching a limit in terms of the paying capacity of individual homeowners, as well as municipalities. Thus, energy consideration in planning low-density developments appears to be the most urgent, as well as the most controversial, and perplexing problem. It has been suggested that even linking "energy efficiency" and "low-density development" constitutes a paradox since urban sprawl is the prime cause of the present energy and environmental overload.

Furthermore, a difficulty lies in the fact that a wastage of energy is, of course, very wrong, but at the same time, immensely delightful. Thus, it is not hard to understand how a two-garage subdivision home built far away from working, shopping, educational and recreational facilities became the great dream for the average North American. In the last few decades, this love affair with a single-family house and a personal car fleet reached mass proportions

AND THE IDEA OF ENJOYING "THE GOOD LIFE" OUTSIDE OF A SUBDIVISION WAS BELIEVED TO BE IMPOSSIBLE. HOMEOWNERSHIP BECAME A PART OF OUR BASIC HUMAN RIGHTS AND THIS BELIEF WAS REINFORCED BY A VARIETY OF GOVERNMENTAL PROGRAMS AND SUBSIDIES. ALTHOUGH THE MARKET MECHANISM WAS GROSSLY DISTORTED, THE BLUEPRINT FOR HAPPINESS WAS ESTABLISHED.

CONSEQUENTLY, THE OVERALL PROCESS OF DEVELOPING A SUBDIVISION - FROM ITS INCEPTION TO ITS SALES CLOSINGS - HAS BEEN STREAMLINED AND ALL THE INVOLVED PARTIES HAVE LEARNED TO PLAY THEIR ROLES. THE SYSTEM APPEARED TO BE VERY SUCCESSFUL AND ATTRACTED WORLD-WIDE ATTENTION AND ENVY.

THUS, IT WAS UNTIL VERY RECENTLY. SUDDENLY, OVERWHELMING EVIDENCE WAS PRESENTED TO SHOW THAT A FUNDAMENTAL ERROR WAS OVERLOOKED: OUR DISREGARD FOR THE COST OF ENERGY AND FOR THE AMOUNT OF ENERGY CONSUMED. A SLAP IN THE FACE...A PUNISHMENT FOR OUR BLINDNESS. BUT, WHAT CAN WE DO NOW?

INEVITABLY, BUT UNDERSTANDABLY, ANY ATTEMPT TO ALTER THE PRESENT WAY OF DOING THINGS MUST MEET

WITH FURIOUS RESISTANCE ON THE PART OF EVERYONE INVOLVED: THE LUMBER INDUSTRY, MANUFACTURERS, LAND DEVELOPERS, BUILDERS, ARCHITECTS, PLANNERS, FINANCIAL INSTITUTIONS, MUNICIPALITIES, PROVINCIAL AND FEDERAL AUTHORITIES, REALTORS, AND, OF COURSE, THE BUYING PUBLIC. SINCE THE CONSTRUCTION INDUSTRY IS OPERATING ON A MUCH LOWER PROFIT MARGIN THAN YEARS AGO, DEVELOPERS ARE ULTRA-SENSITIVE TO THE SENTIMENTS OF THE MARKET. THE VICIOUS CIRCLE APPEARS TO BE CLOSED.

HOW, UNDER THESE CIRCUMSTANCES, CAN WE INTRODUCE A BETTER WAY OF DOING THINGS?

EVEN A CURSORY ANALYSIS OF THE PRESENT SITUATION WOULD CONVINCE US THAT ANY REMEDIAL ACTION WOULD REQUIRE THE CO-OPERATION OF ALL THE PARTIES INVOLVED. FIRST, THERE IS A NEED FOR CO-OPERATION IN TERMS OF A COLLECTIVE AGREEMENT AND SUPPORT FOR THE NECESSARY CHANGES, AND SECONDLY, THERE IS A NEED FOR CO-OPERATION BETWEEN INDIVIDUAL PARTIES. AS NEVER BEFORE, THE DEVELOPER, THE MUNICIPAL PLANNER, THE ARCHITECT AND THE REALTOR MUST WORK CLOSE TOGETHER. WITHOUT THIS CONCERTED EFFORT, ANY ATTEMPT TO BUILD ENERGY-EFFICIENT COMMUNITIES WOULD BE A FUTILE EXERCISE.

Great emphasis has to be placed on education and information dissemination. This has been done for some time now, and we are continuing to do so. But to convince and secure co-operation on the required scale demands more time. It follows then that we are not going to experience any dramatic changes overnight. The process of transformation will be gradual.

Since we wish to proceed with changes as slowly as circumstances allow us to, we would like to begin with simple, inexpensive improvements. To be very efficient does not always require "Buck Rogers" style technologies. There are many minor adjustments and "soft paths" to follow which, in summary, could accomplish up to a 50% cut on energy consumption without any draconian measures applied.

The first step in this direction is to learn - or re-learn - the use of common sense: how to take advantage of the natural environment, how to build houses which warm the people inside and not the sky.

This report is devoted to this first step.

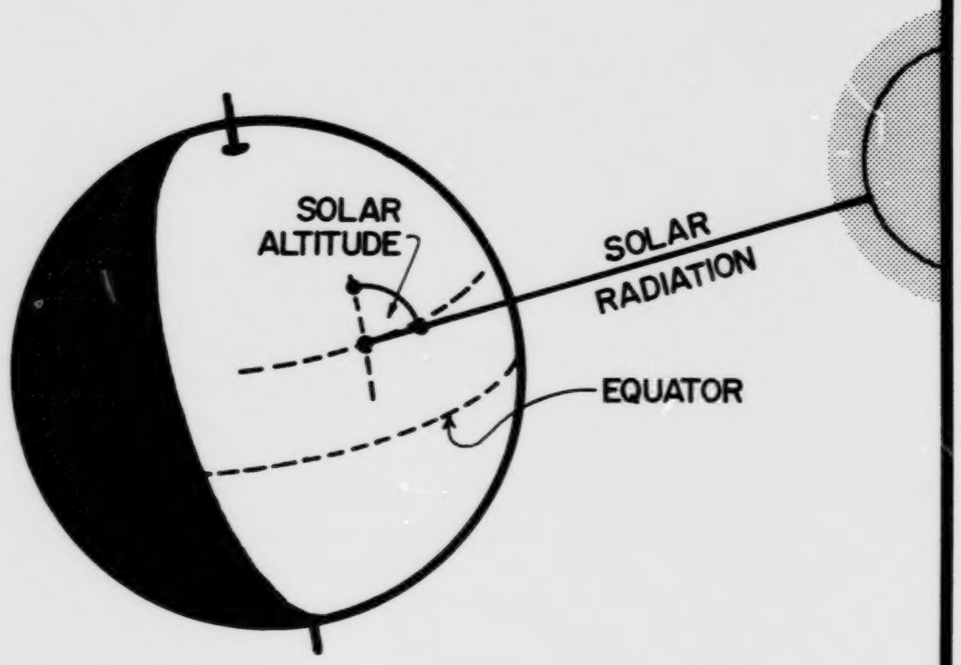
THE ABSOLUTE MINIMUM WE HAVE TO KNOW ABOUT THE SUN, SOLAR RADIATION AND CELESTIAL MECHANICS...

THAT PART OF THE SKY WHICH SHOULD BE CONSIDERED OUR GOD-GIVEN RIGHT AND BE PROTECTED BY LAW IS CALLED A "SKY WINDOW".

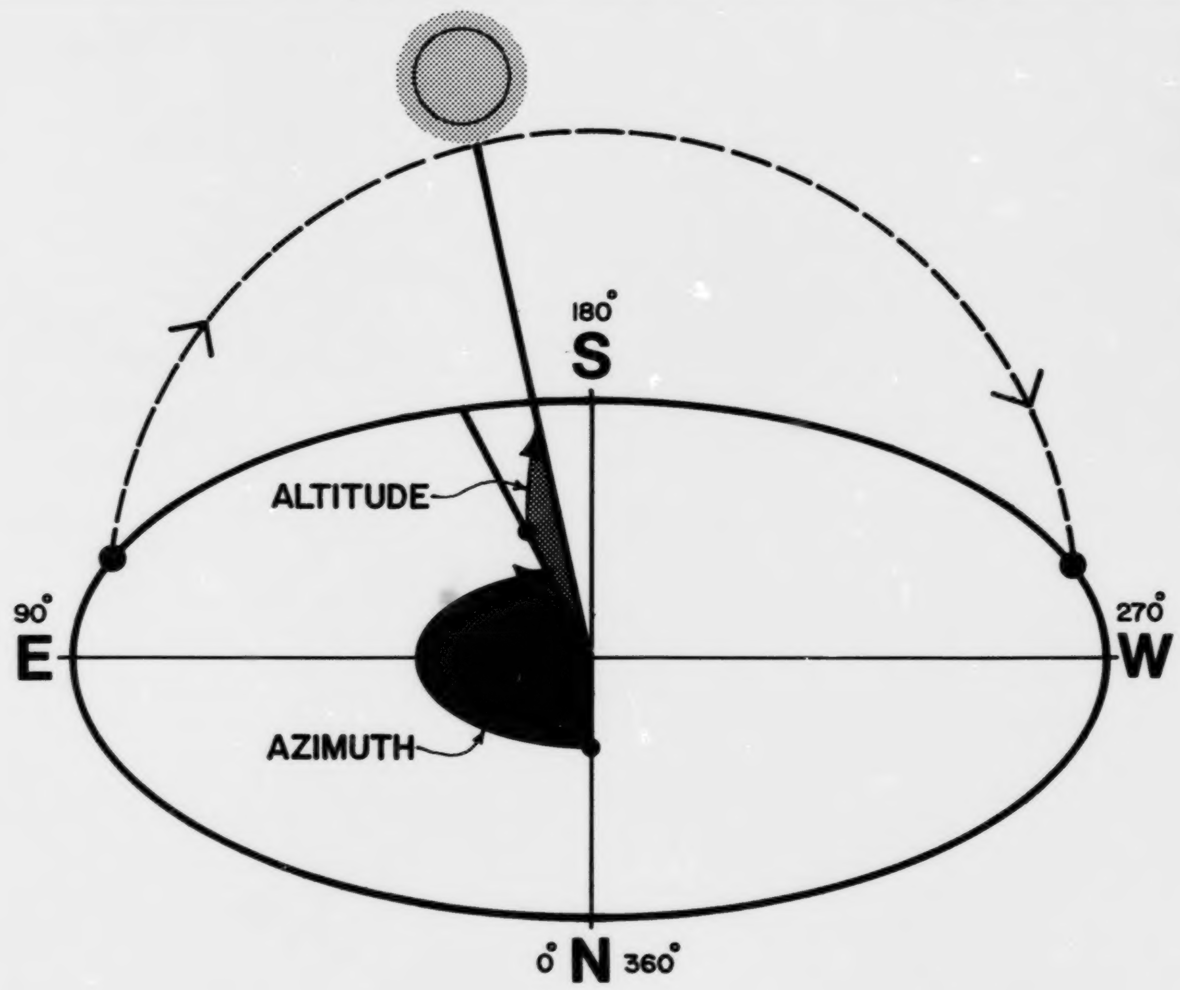
THE MORE SUNLIGHT A SIGHT RECEIVES, THE GREATER IS IT'S POTENTIAL FOR USING SOLAR ENERGY. THE AMOUNT OF SUNLIGHT A GIVEN SPOT ON EARTH RECEIVES DEPENDS ON HOW NEAR TO PERPENDICULAR THE SUN'S RAYS ARE TO THE SITE. THE CLOSER THE SUN IS TO BEING DIRECTLY OVERHEAD, THE GREATER IS ITS INTENSITY; THE MORE TILTED THE SUN IS FROM THE PERPENDICULAR, THE LESS INTENSE ARE ITS RAYS.

THE AMOUNT OF ENERGY RECEIVED FROM THE SUN AT A GIVEN LOCATION DEPENDS ON THREE FACTORS: <u>THE TIME OF DAY</u>, <u>THE LATITUDE</u>, <u>AND THE TIME OF YEAR</u>.

THE SUN'S LIGHT IS MOST INTENSE AT SOLAR NOON, WHEN IT REACHES ITS HIGH POINT IN THE SKY FOR THE DAY, AND IT IS WEAKEST AT SUNRISE AND SUNSET. THE SECOND FACTOR, LATITUDE, OR THE DISTANCE NORTH OR SOUTH OF THE EARTH'S EQUATOR, ALSO AFFECTS THE SUN'S POSITION IN THE SKY. BECAUSE OF THE EARTH'S CURVATURE, THE FURTHER NORTH ONE GOES IN THE NORTHERN HEMISPHERE, THE LOWER THE SUN AND THE LESS ITS INTENSITY. FINALLY THE CHANGE OF SEASONS ALSO AFFECTS THE INTENSITY OF SUNLIGHT, PARTICULARLY IN LATITUDES DISTANT FROM THE EQUATOR. IF THE EARTH'S AXIS WERE PERPENDICULAR TO THE PLANE OF THE EARTH'S ORBIT AROUND THE SUN, THERE WOULD BE NO CHANGE OF SEASON. SINCE THE EARTH'S AXIS IS TILTED AT ABOUT 23.5 DEGREES FROM THE PERPENDICULAR, THE NORTHERN HEMISPHERE IS TILTED SLIGHTLY TOWARDS THE SUN IN SUMMER AND SLIGHTLY AWAY FROM IT IN WINTER.

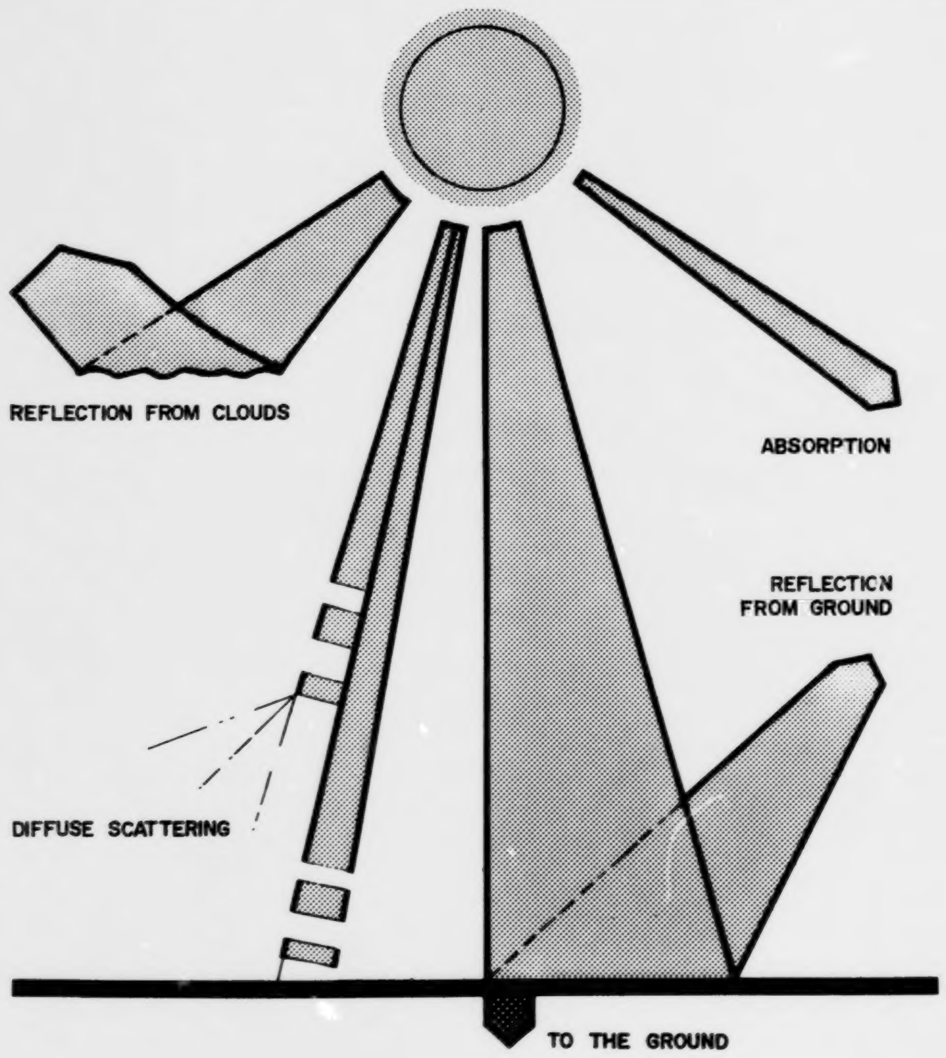


SOLAR ENERGY



THE SUN'S POSITION IN THE SKY

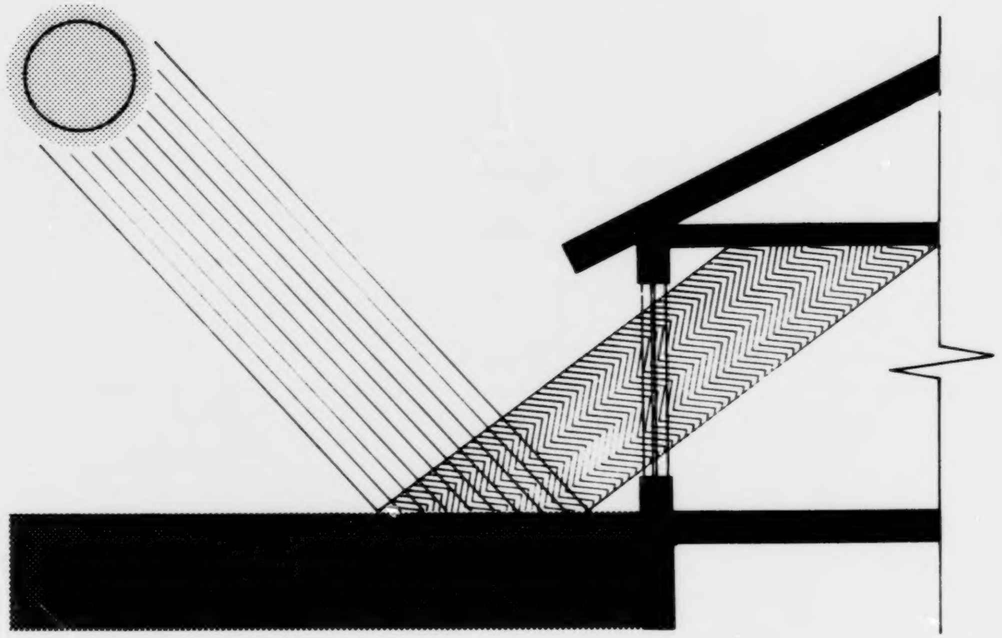
THE SOLAR RADIATION REACHING GROUND LEVEL IS CONSIDERABLY LESS BECAUSE OF A SERIES OF LOSSES WHICH OCCUR WHEN THE RADIATION PASSES THROUGH THE EARTH'S ATMOSPHERE. PART OF THE INCOMING SOLAR RADIATION IS REFLECTED BY THE SURFACE OF CLOUDS, AND ATMOSPHERIC INGREDIENTS. A CERTAIN AMOUNT IS SCATTERED BY MOLECULES IN THE ATMOSPHERE, BUT SOME OF THIS IS REGAINED AS DIFFUSE RADIATION. PART OF THE RADIATION RECEIVED AT GROUND LEVEL IS REFLECTED BY THE EARTH'S SURFACE, BUT MOST OF THE ENERGY IS ABSORBED. IT CHANGES TO HEAT AND RAISES THE TEMPERATURE OF THE AIR, THE GROUND, AND SURROUNDING OBJECTS. THE INTENSITY OF THE RADIATION RECEIVED ON THE EARTH'S SURFACE INCREASES WITH THE HEIGHT ABOVE SEA LEVEL, BECAUSE LESS IS LOST TO THE ATMOSPHERE.



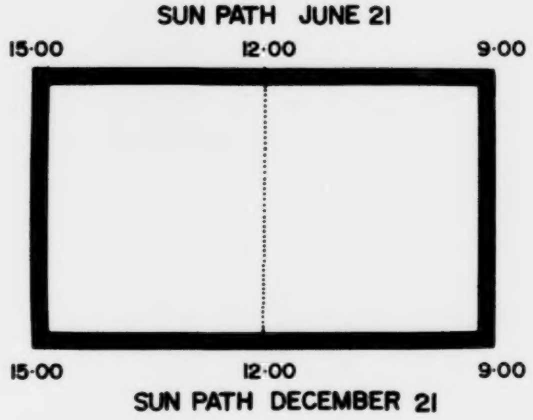
SOLAR RADIATION

PERCENTAGE OF SOLAR RADIATION REFLECTED

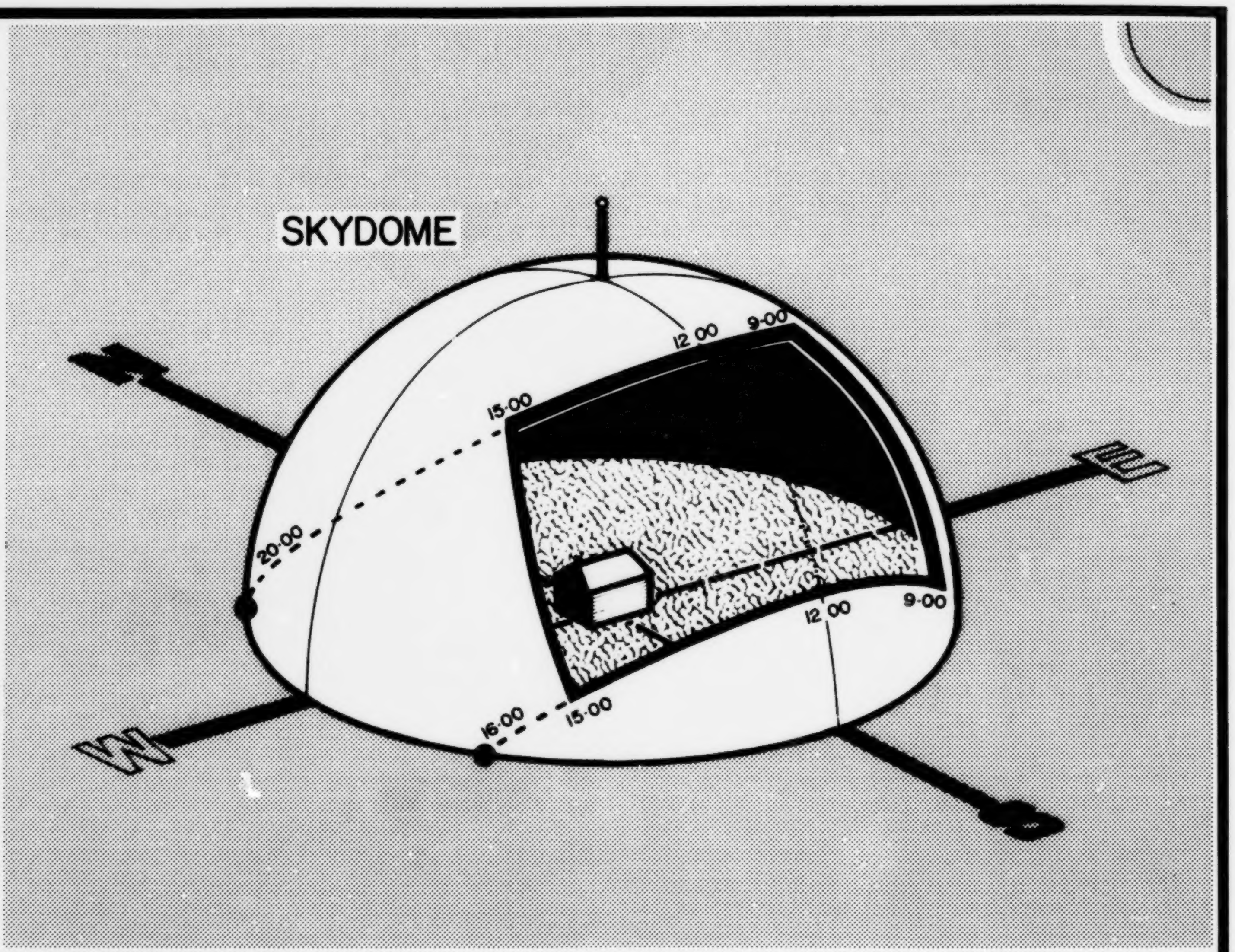
NATURE OF SURFACE		PERCENTAGE OF REFLECTION
GROUND, DRY	.....	10 – 25
GROUND, WET	.....	8 – 9
SAND, DRY	.....	18 – 30
SAND, WET	.....	9 – 18
ROCK	.....	12 – 15
GLASS	.....	32
GREEN GRASS	.....	3 – 15
GREEN LEAVES	.....	25 – 32
BRICKS	.....	23 – 48
ASPHALT	.....	15
CITY AREA	.....	10
SNOW	UP TO.....	90 %
WATER POOL	UP TO.....	90 %



REFLECTION OF SOLAR RADIATION



THE SUN WINDOW IS AN OPENING CUT IN AN IMAGINARY SKYDOME. ANY OBSTRUCTION BY A NATURAL OR MAN-MADE OBJECT COULD MAKE AN ACTIVE AND/OR PASSIVE SOLAR SYSTEM INEFFECTIVE. THE SUN WINDOW IS A PHYSICAL REPRESENTATION OF "THE RIGHT TO SUN LIGHT".

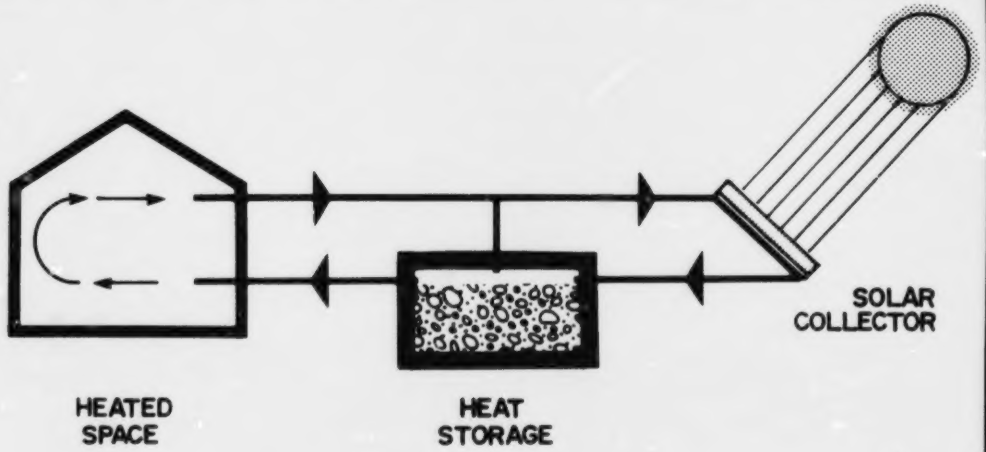


SUN WINDOW

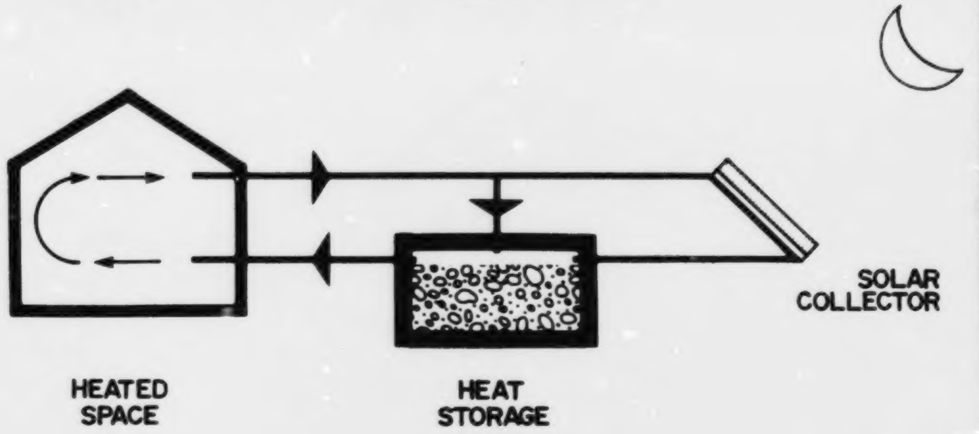
ACTIVE SOLAR ENERGY SYSTEMS ARE VERY SOPHISTICATED MECHANICAL DEVICES. THEIR LONG-RANGE FUTURE IS UNDOUBTEDLY VERY PROMISING.

AT PRESENT, THE ECONOMY OF AN ACTIVE SOLAR SYSTEM HAS TO BE MEASURED BY LIFE-CYCLE COSTING. THE INITIAL CAPITAL EXPENDITURE IS USUALLY HIGH.

AN ACTIVE SOLAR SYSTEM IS A DEVICE USED TO TRANSFORM SOLAR RADIATION TO USABLE HEAT. ENERGY ACCUMULATED IN THE COLLECTOR IS TRANSFERRED BY AIR, WATER, OR OTHER FLUIDS TO THE PLACE WHERE IT IS USED, OR TO THE PLACE WHERE IT IS STORED FOR FUTURE USE. THE MOST COMMON FORM OF ACTIVE COLLECTOR IS KNOWN AS A "FLAT - PLATE COLLECTOR" WHICH IS MERELY AN INSULATED BOX WITH A GLASS COVER AND AN ABSORBER PLATE. SOLAR RADIATION ENTERING THE GLASS COVER IS CAPTURED BY THE PLATE. A FLUID IS CIRCULATED THROUGH OR OVER THE PLATE TO REMOVE THE HEAT FROM THE COLLECTOR TO ITS POINT OF USE.

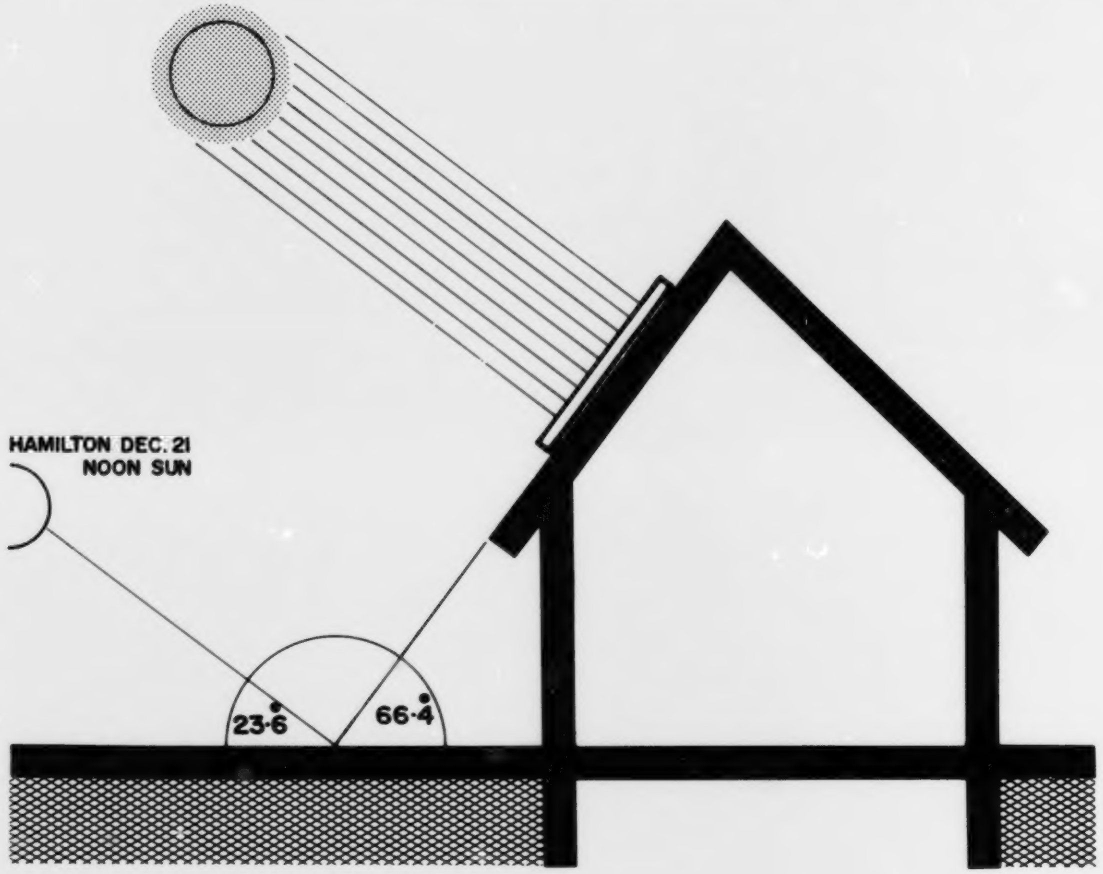


THERE ARE SOME OTHER TYPES OF COLLECTORS USED IN ACTIVE SYSTEMS. A COLLECTOR CAN BE MOUNTED SO THAT IT FOLLOWS THE PATH OF THE SUN ACROSS THE SKY. THIS INCREASES ITS ABILITY TO CAPTURE SOLAR RADIATION. SUCH TYPES OF SYSTEMS ARE KNOWN AS "TRACKING COLLECTORS." REFLECTORS AND LENSES CAN BE USED TO INCREASE THE SOLAR RADIATION REACHING THE ABSORBER PLATE. THESE ARE KNOWN AS "CONCENTRATING COLLECTORS" AND, LIKE TRACKING COLLECTORS, GENERATE HIGHER TEMPERATURES THAN STATIONARY FLAT-PLATE COLLECTORS. YET ANOTHER KIND OF COLLECTOR, THE "EVACUATED TUBE" SYSTEM, USES A VACUUM BETWEEN VARIOUS GLASS TUBES NESTED WITHIN ONE ANOTHER TO REDUCE HEAT LOSSES. THESE COLLECTORS OPERATE AT HIGHER EFFICIENCIES AND TEMPERATURES THAN FLAT-PLATE COLLECTORS.



CURRENTLY MARKETED ACTIVE SOLAR SYSTEMS ARE RAPIDLY IMPROVING IN PERFORMANCE AND RELIABILITY. BEFORE INCORPORATING AN ACTIVE SOLAR SYSTEM INTO YOUR DEVELOPMENT, CONSULT SEVERAL REPUTABLE MANUFACTURERS AND COMPARE.

ACTIVE SOLAR ENERGY SYSTEM



FOR THE BEST WINTER SUN ENERGY HARVEST, THE USUALLY RECOMMENDED SOLAR COLLECTOR ANGLE IS 60 DEGREES .

SOLAR COLLECTOR ANGLE

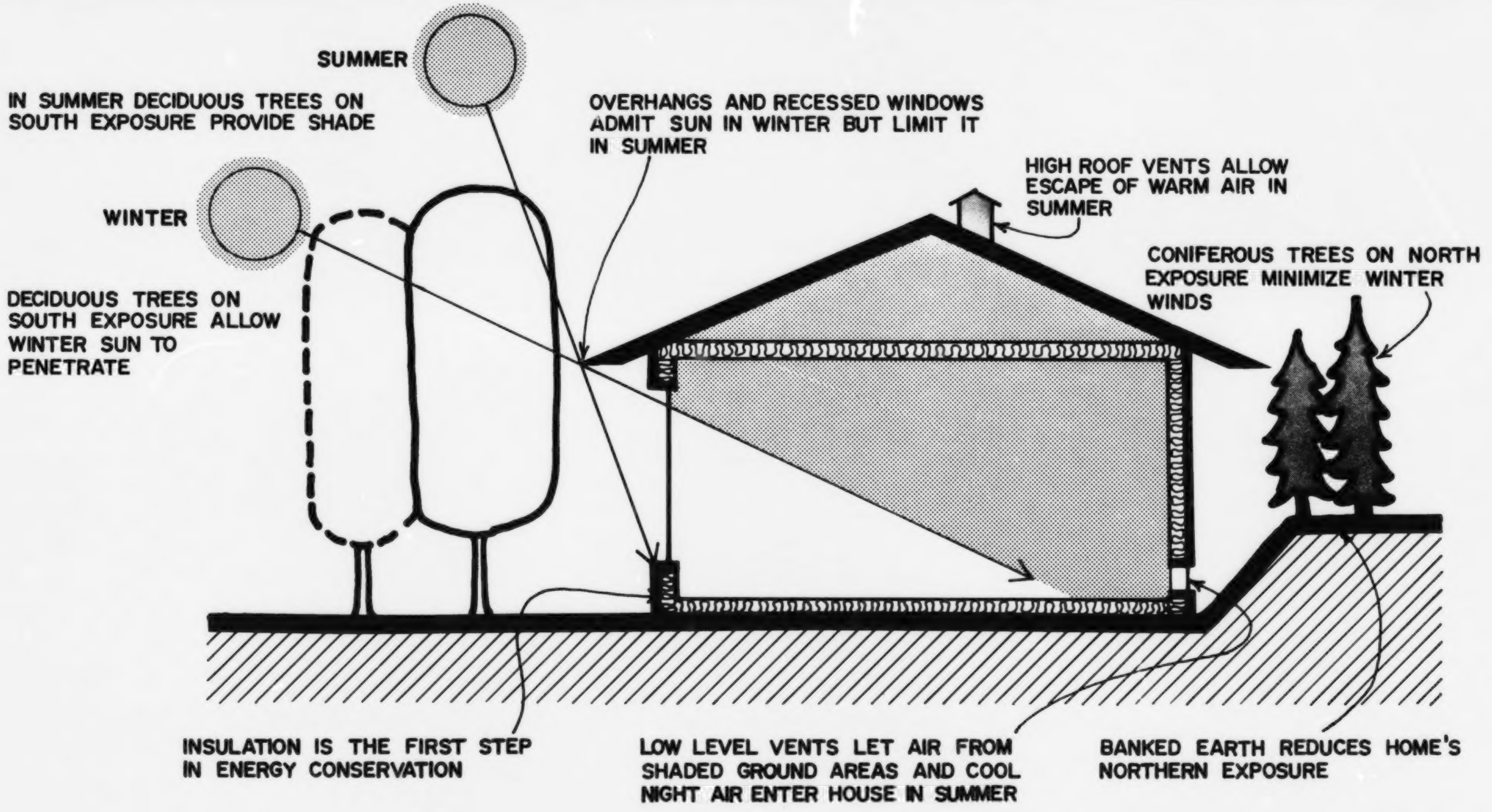
THE PASSIVE SOLAR SYSTEM IS ONE OF MANY APPROACHES TO GREATER ENERGY EFFICIENCY IN URBAN AND REGIONAL PLANNING, AND IN ARCHITECTURAL DESIGN. ALTHOUGH THIS APPROACH IS AS OLD AS MANKIND, MOST OF THE KNOWLEDGE RELATED TO IT HAS DISAPPEARED WITHOUT A TRACE DURING THE LAST SEVERAL DECADES. THUS, SKILLS MUST BE RE-LEARNED AND IDEAS RE-INVENTED. WE ARE IN THE MIDST OF A RENAISSANCE PROCESS.

THE BASIC AIM OF THE PASSIVE SOLAR APPROACH OR SOFT PATH IS TO ACHIEVE HIGH ENERGY EFFICIENCY BY USING SIMPLE, INEXPENSIVE MEANS. IT HAS BEEN ESTABLISHED THAT THIS APPROACH IS DIRECTLY COMPETITIVE WITH A CONVENTIONAL SYSTEM, BOTH IN TERMS OF ECONOMY AND THERMAL COMFORT. THE DIFFICULTY LIES IN THE FACT THAT THE SOFT PATH REQUIRES "FRONT-END INVESTMENT", THE INVESTMENT OF INTELLECTUAL ENERGY.

IN OTHER WORDS, WE CAN ACHIEVE A VERY HIGH LEVEL OF ENERGY EFFICIENCY AND AVOID THE USE OF VERY EXPENSIVE AND VERY COMPLEX TECHNOLOGIES; THE DESIGN, HOWEVER, MUST BE TUNED TO THE

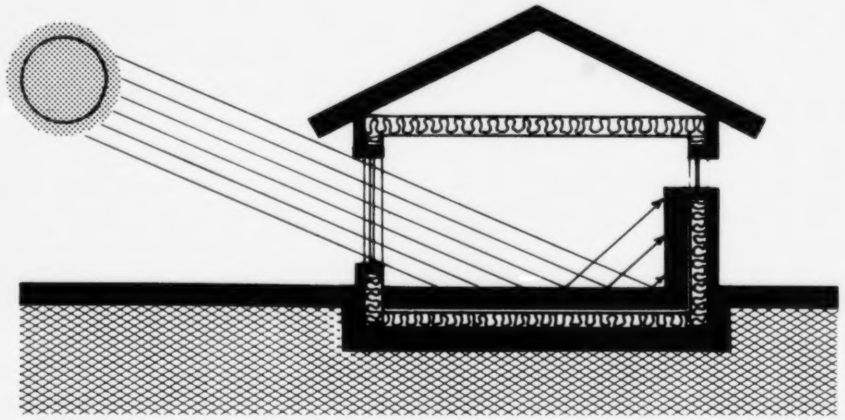
SURROUNDINGS. THE INCORPORATION OF TOPOGRAPHICAL AND CLIMATIC FACTORS CONSTITUTES THE INCORRUPTIBLE PRINCIPLE OF A SOPHISTICATED DESIGN. UNFORTUNATELY, THIS TYPE OF SOPHISTICATION HAS NEVER BEEN PART OF OUR TRADITION.

NOW IS THE TIME TO ESTABLISH SUCH A TRADITION.



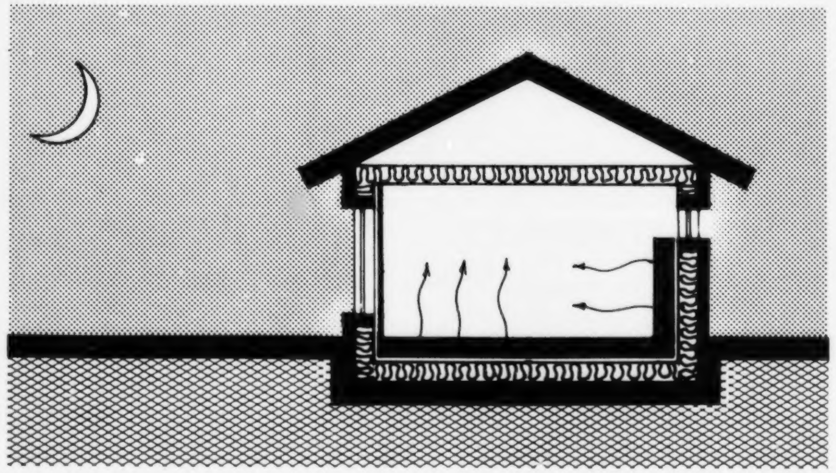
ELEMENTS OF A PASSIVE SOLAR SYSTEM

IN THE DAY, THE SUN'S RADIATION PASSES THROUGH THE SOUTH — FACING GLASS, ABSORBED AND STORED BY THE MASS OF THE HOUSE (CONCRETE FLOOR AND WALLS).



DAY

AT NIGHT AN INSULATED SHUTTER CLOSES THE GLASS AND PROTECTS AGAINST HEAT LOSS. HEAT RADIATES WITHIN.



NIGHT

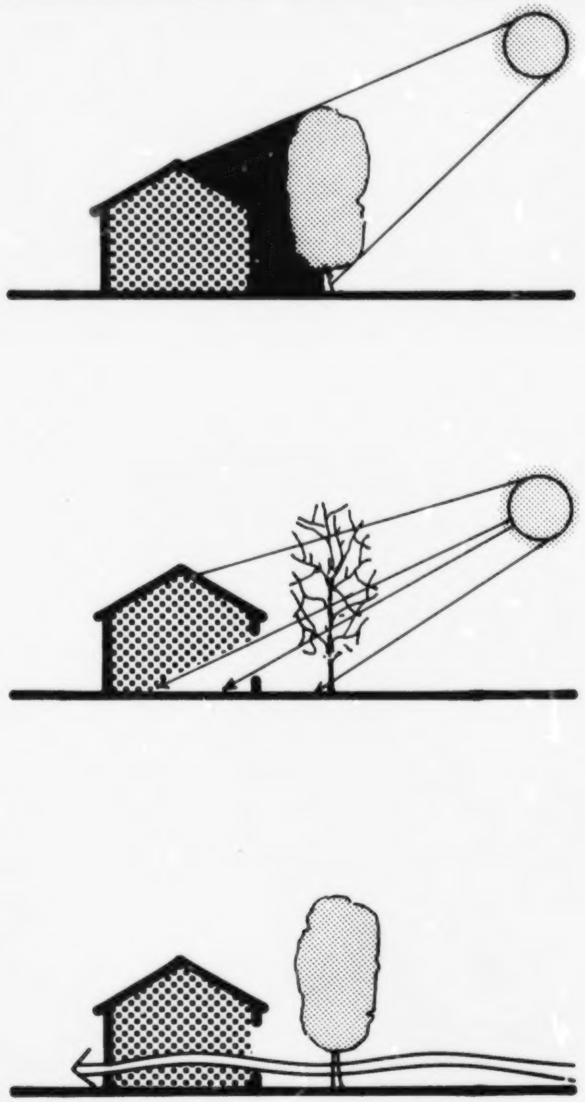
THE MECHANICS OF A PASSIVE SOLAR SYSTEM

DECIDUOUS TREES PLANTED ON THE SOUTH AND WEST SIDES OF A BUILDING PROVIDE :

COOLING SHADE IN SUMMER

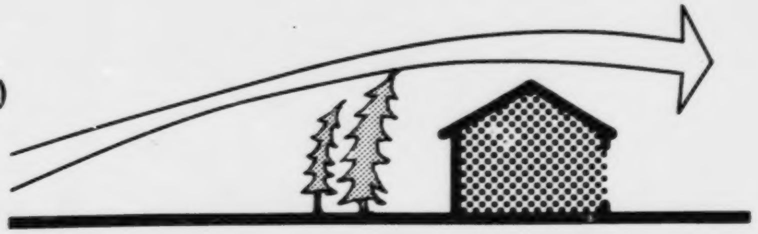
SUNLIGHT IN WINTER

COOLING SUMMER BREEZE

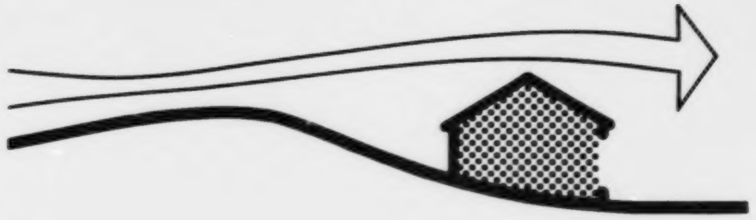


PASSIVE SOLAR DESIGN PRINCIPLES

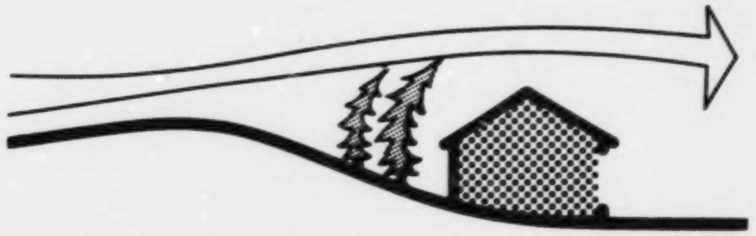
CONIFEROUS TREES (EVERGREEN) PLANTED ON THE NORTH AND WEST SIDES OF A BUILDING PROTECT FROM WINTER WINDS



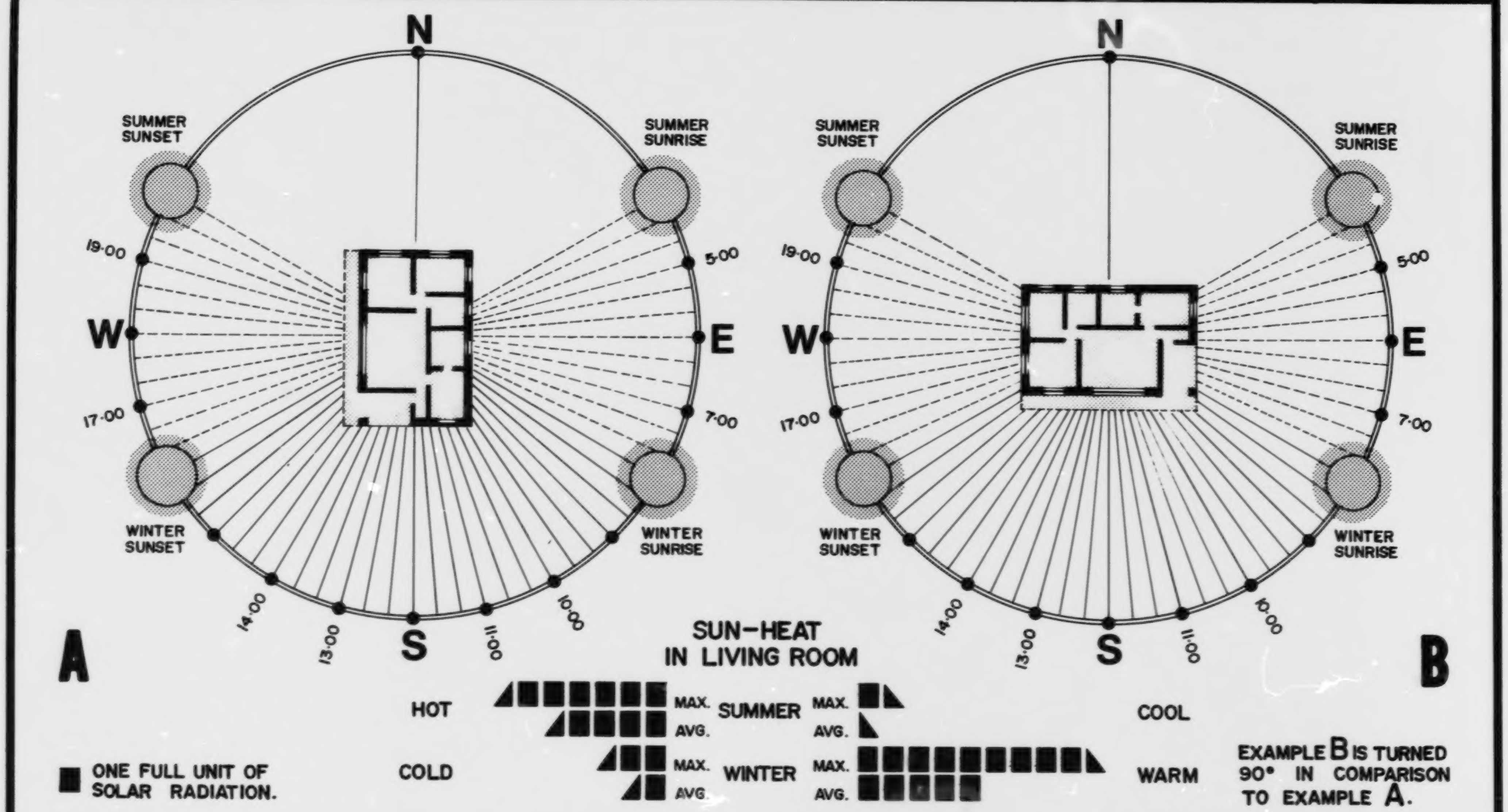
LAND FORM DEFLECTS WINTER WINDS



EVERGREEN TREES PROVIDE ADDITIONAL PROTECTION

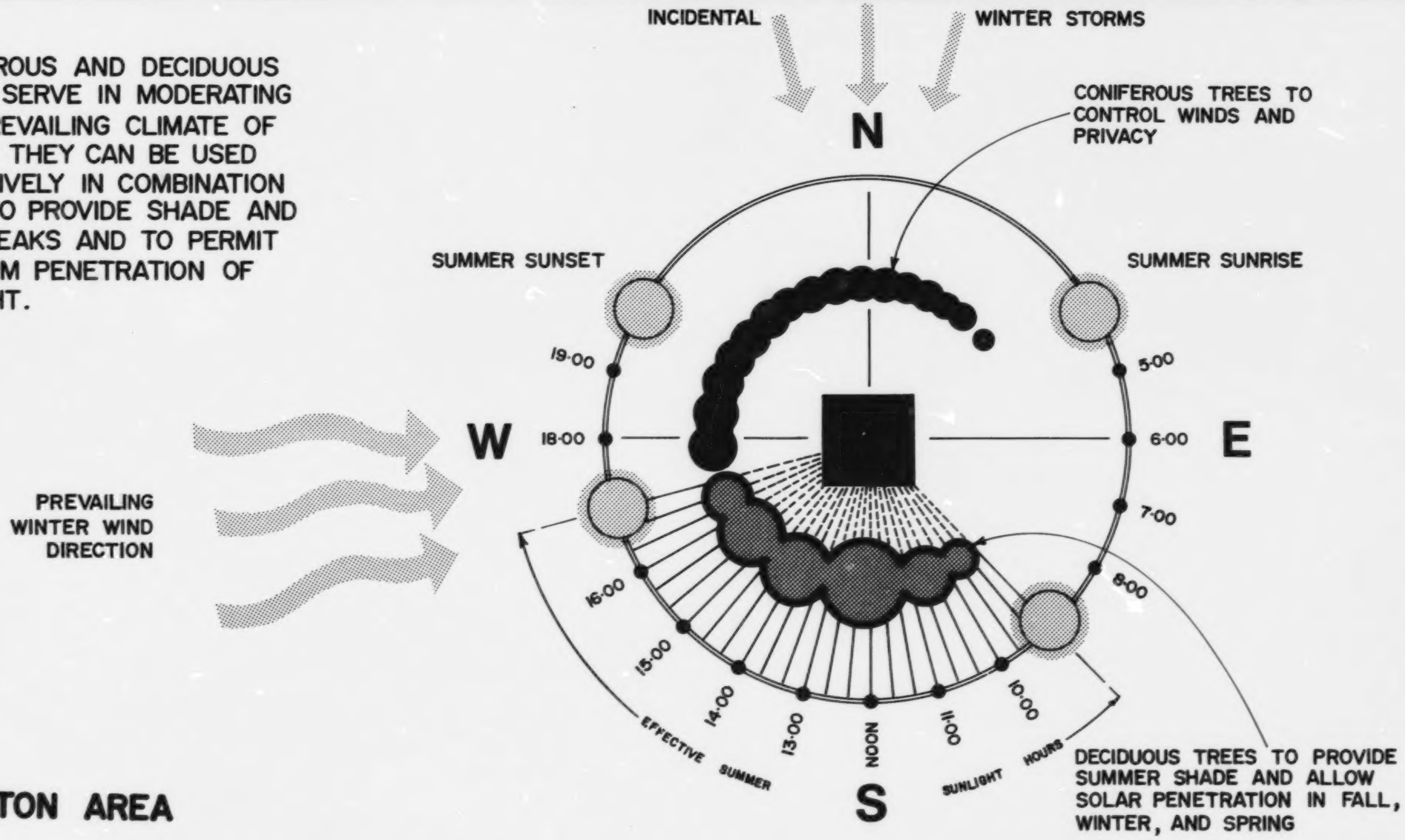


PASSIVE SOLAR DESIGN PRINCIPLES



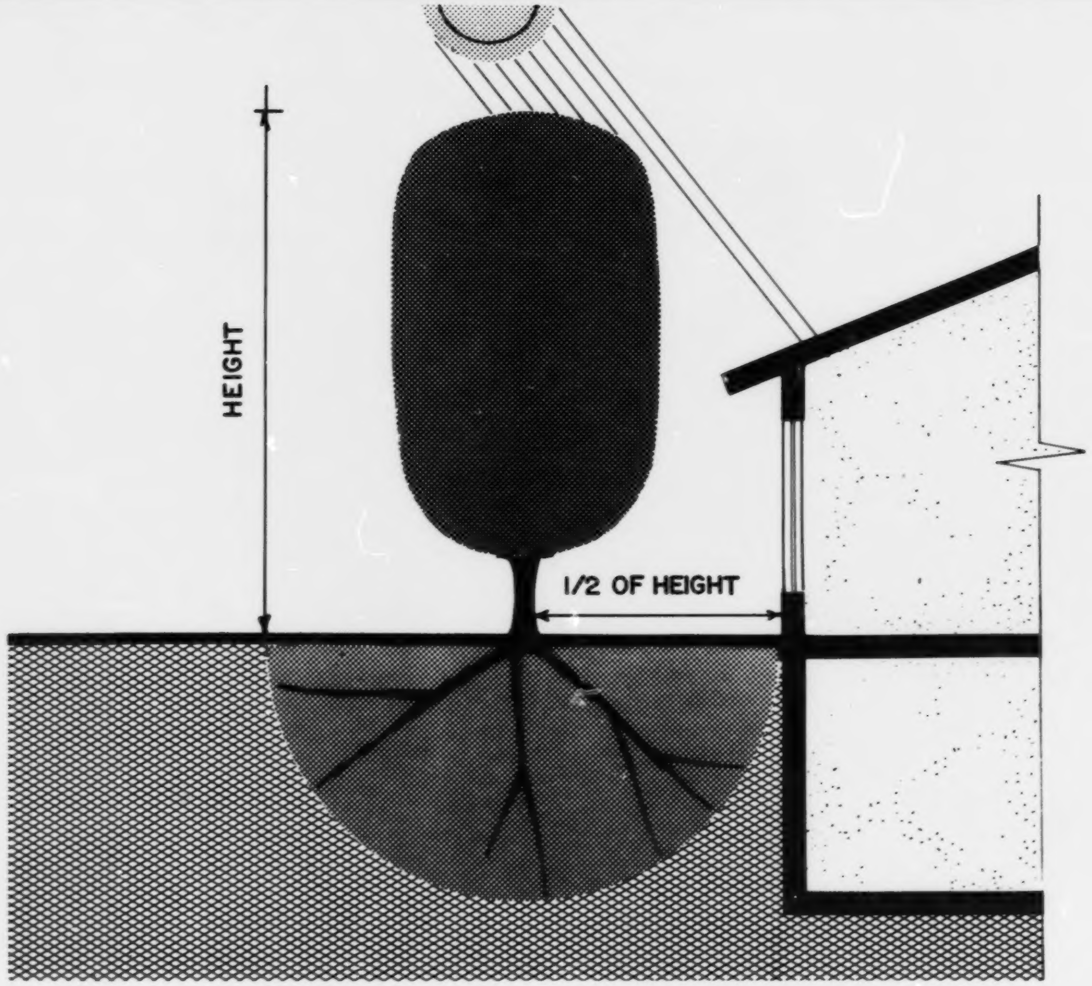
HOUSE ORIENTATION AND THERMAL COMFORT

CONIFEROUS AND DECIDUOUS TREES SERVE IN MODERATING THE PREVAILING CLIMATE OF A SITE. THEY CAN BE USED EFFECTIVELY IN COMBINATION BOTH TO PROVIDE SHADE AND WINDBREAKS AND TO PERMIT MAXIMUM PENETRATION OF SUNLIGHT.



HAMILTON AREA

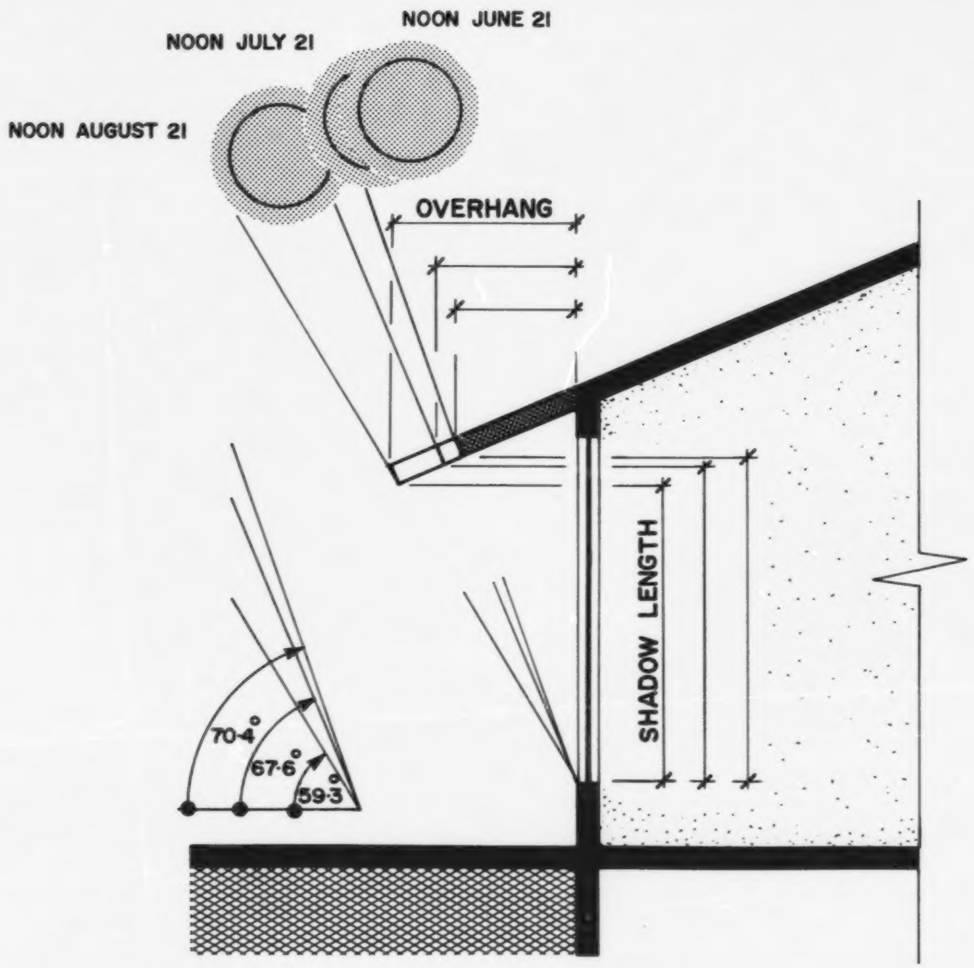
SOLAR LANDSCAPING



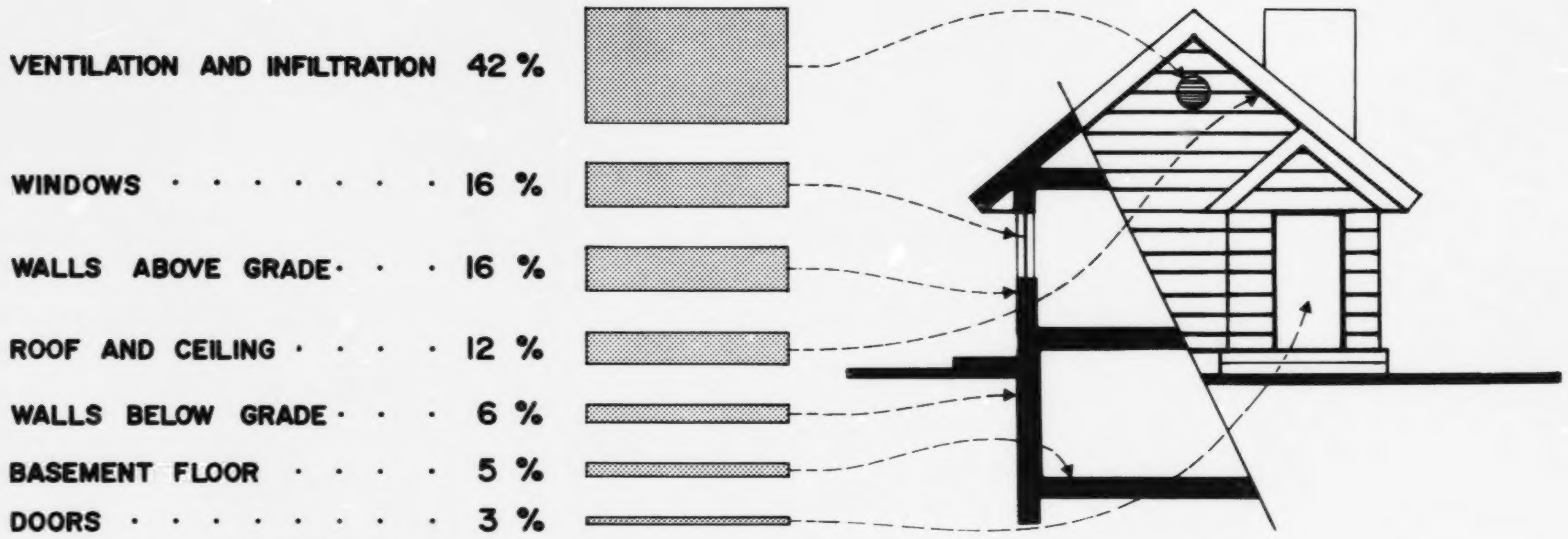
ALL TREES SHOULD BE PLANTED AT A SUFFICIENT DISTANCE FROM THE STRUCTURE SO THAT THEIR ROOT SYSTEM DOES NOT INTERFERE WITH THE BUILDING FOUNDATIONS. MOST TREES EXTRACT A CONSIDERABLE AMOUNT OF MOISTURE FROM THE SOIL, AND EXCESSIVE DEHYDRATION CAN CAUSE DIFFERENTIAL SETTLEMENT OF BELOW-GROUND CONSTRUCTION. A RELIABLE RULE OF THUMB FOR DECIDUOUS TREES IS THAT THE ROOT SYSTEM WILL EXTEND RADIALLY TO A DISTANCE EQUAL TO AT LEAST HALF THE HEIGHT OF THE TREE. THUS, ANY TREE SHOULD BE PLACED NO CLOSER THAN THE EXPECTED EXTENT OF ITS ROOT SYSTEM AT FULL MATURITY.

SOLAR LANDSCAPING

THE OVERHANG IS THE MOST EFFECTIVE METHOD FOR SHADING SOUTH-FACING GLASS IN SUMMER. THIS SHADING DEVICE IS SIMPLY A ROOF PROJECTION. THE OPTIMUM PROJECTION OF THE OVERHANG FROM THE FACE OF THE BUILDING IS DEPENDENT UPON WINDOW HEIGHT, LATITUDE AND CLIMATE.



OVERHANG



THE HEAT LOSS DISTRIBUTION TABLE INDICATES THAT AN EFFICIENTLY PERFORMING ENERGY CONSERVATION HOUSE WOULD REQUIRE THE FOLLOWING:

- PROPERLY CALCULATED AND INSTALLED INSULATION
- AIR EXCHANGE CONTROL
- EXCELLENT CRAFTSMANSHIP
- SELECTED WINDOWS AND ENTRANCE DESIGNS
- A HEAT RECOVERY SYSTEM

HEAT LOSS

EVEN IN HAMILTON'S LATITUDE, A FULL UTILIZATION OF THE DESIGN PRINCIPLES OF A PASSIVE SOLAR SYSTEM AND A SOFT TECHNOLOGY APPROACH WOULD MAKE POSSIBLE THE COMPLETE ELIMINATION OF A CONVENTIONAL HEATING SYSTEM. THUS, THE ANNUAL HEATING BILL COULD EQUAL ZERO.

HOWEVER, A GREAT DEAL OF METICULOUS PLANNING AND DESIGN IS NECESSARY BEFORE THE COMMENCEMENT OF DIGGING. THE TIME AND MONEY SPENT ON PLANNING AND DESIGN IS THE WISEST INVESTMENT.

OBVIOUSLY, THIS APPROACH WILL REQUIRE A SIGNIFICANT CHANGE IN ATTITUDE ON THE PART OF THE CONSTRUCTION INDUSTRY.

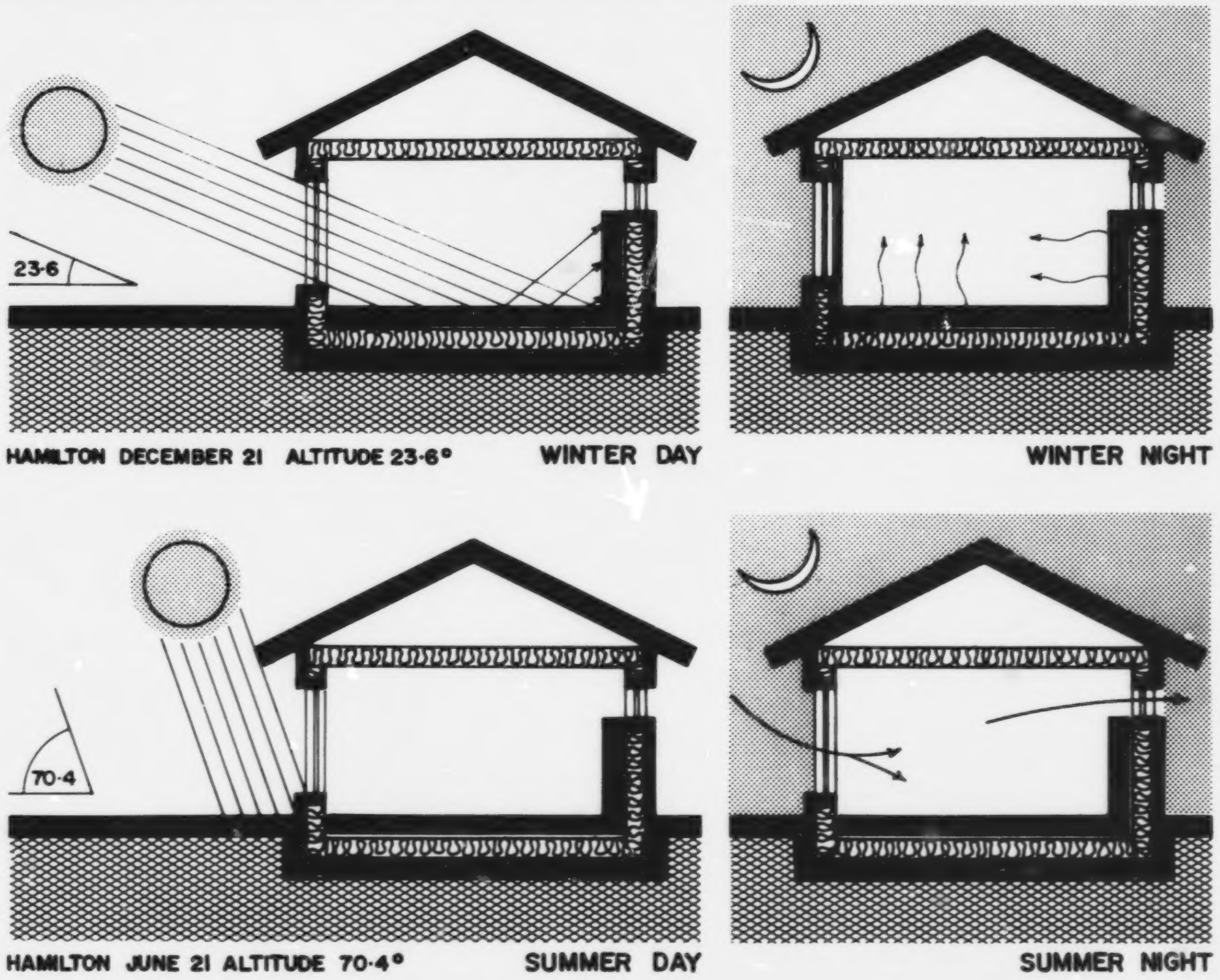
THE FOLLOWING IS A BRIEF REVIEW OF THE MOST COMMON CURRENT PASSIVE SOLAR SYSTEMS.

DIRECT PASSIVE GAIN

IN THE HEATING SEASON, SOUTH-FACING GLAZED WINDOWS ARE NET GAINERS OF SOLAR RADIATION. IN FACT, A SOUTH-FACING WINDOW CONSERVES MORE HEATING ENERGY OVER THE LONG TERM THAN ANY AMOUNT OF WALL INSULATION.

FURTHERMORE, PROVIDE THERMAL SHUTTERS AND BLINDS OR MOVABLE WINDOW INSULATION IN ORDER TO REDUCE OUTWARD HEAT LOSSES AT NIGHT.

IN SUMMER, THE HOUSE CAN BE PROTECTED FROM SOLAR RADIATION BY THE USE OF OVERHANGS, VERTICAL LOUVERS AND EVEN DECIDUOUS TREES.



MASS WALLS

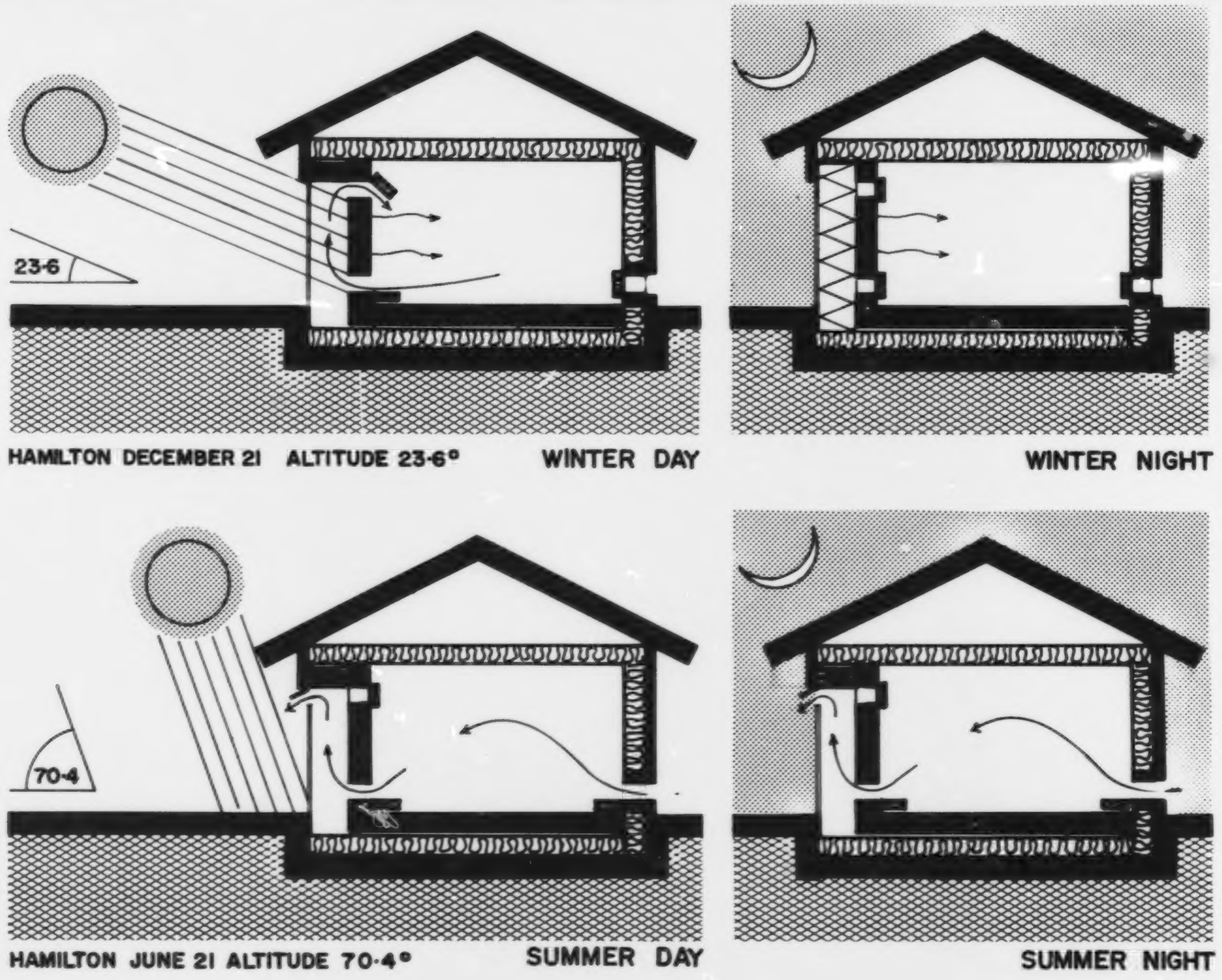
TWO TYPES OF INDIRECT GAIN MASS WALL PASSIVE SYSTEMS ARE IN USE .

- WATERWALL : ACTS AS THE HEAT SYSTEM ELEMENT;
- TROMBE WALL: IS A CONCRETE OR SOLID MASONARY WALL SERVING AS THE HEAT STORAGE ELEMENT.

BOTH MASS SYSTEMS ARE POSITIONED BEHIND VERTICAL SOUTH—FACING GLAZING.

THE AIR BETWEEN THE GLAZING AND THE VERTICAL MASS BECOMES HEATED. IT IS POSSIBLE TO NATURALLY CONVECT THIS AIR TO THE HEATED SPACE BY THE PROVISION OF DAMPERS AT THE TOP AND BOTTOM OF THE MASS STORAGE WALL.

IN THE SUMMER, BY CLOSING THE DAMPER AT THE TOP OF THE WALL AND OPENING ONE TO THE EXTERIOR, IT IS POSSIBLE TO USE THE SAME CONVECTIVE FLOW TO DRAW AIR INTO THE BUILDING THROUGH A DAMPER ON THE NORTH SIDE AND THEREFORE CONVECTIVELY COOL THE BUILDING.

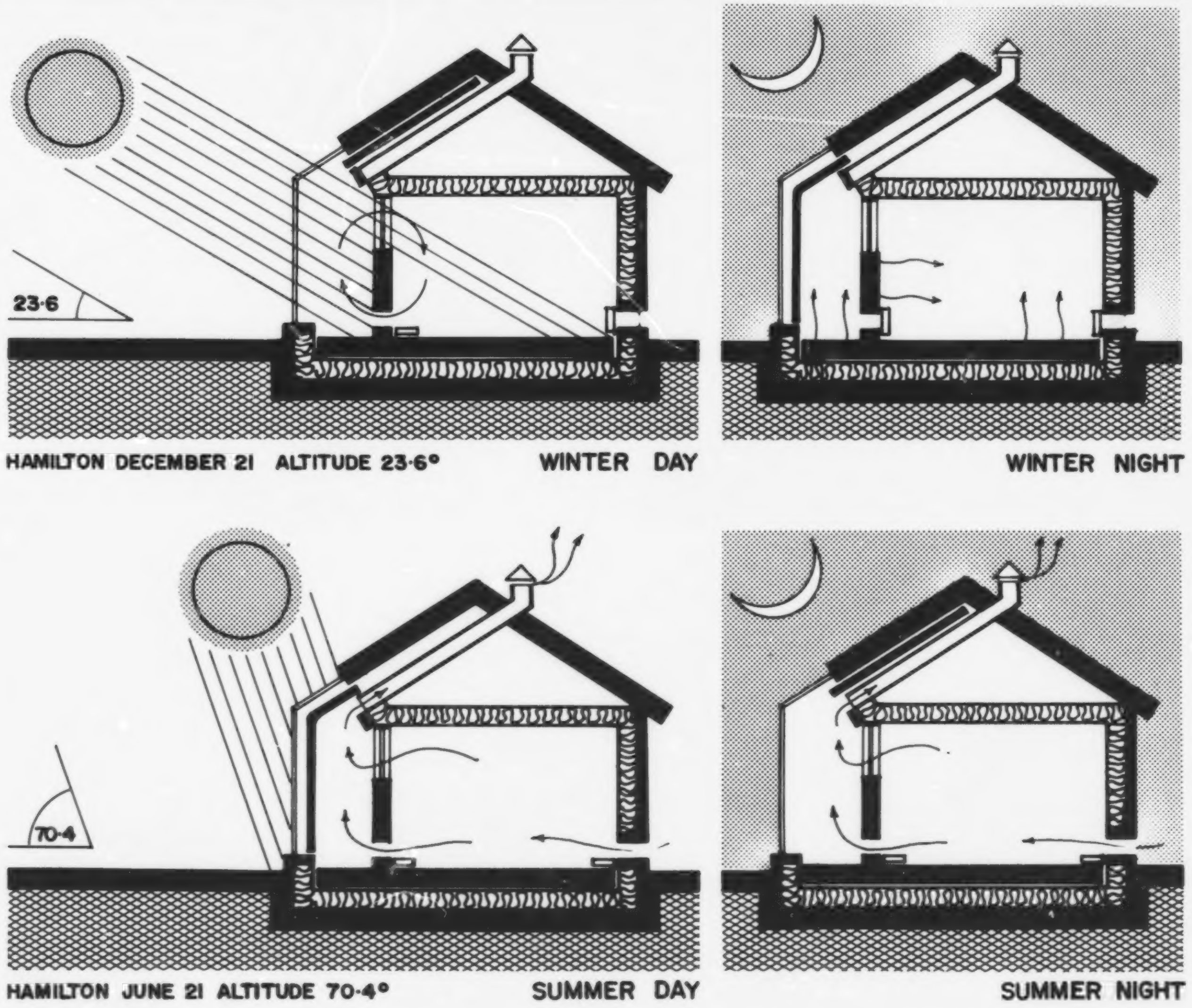


INDIRECT PASSIVE GAIN

SOLAR RADIATION IS ADMITTED INTO THE BUILDING BY SOUTH – FACING WINDOWS AND SKYLIGHTS. THE SPACES DIRECTLY HEATED ARE ANCILLARY ARCHITECTURAL SPACES SUCH AS GREEN HOUSES, ATRIA, SUNROOMS, ETC. WHICH ARE ATTACHED TO THE PRINCIPAL LIVING SPACES.

SOLAR RADIATION MAY BE DIRECTLY TRANSMITTED FROM THE SUNSPACE TO THE LIVING SPACE BY GLAZING. DOORS OR DAMPERS MAY BE OPENED TO PERMIT NATURAL CONVECTIVE HEAT FLOW WITHIN THE PRIME LIVING SPACES.

IN THE SUMMER, A SUNSPACE MAY BE USED TO CONVECTIVELY COOL THE LIVING SPACE OF A BUILDING BY OPERATING A VENT TO THE OUTDOORS FROM THE TOP OF THE SUNSPACE. COOL AIR IS THEN DRAWN THROUGH THE LIVING SPACE TO REPLACE HEATED AIR CONVECTED OUT OF THE SUNSPACE.



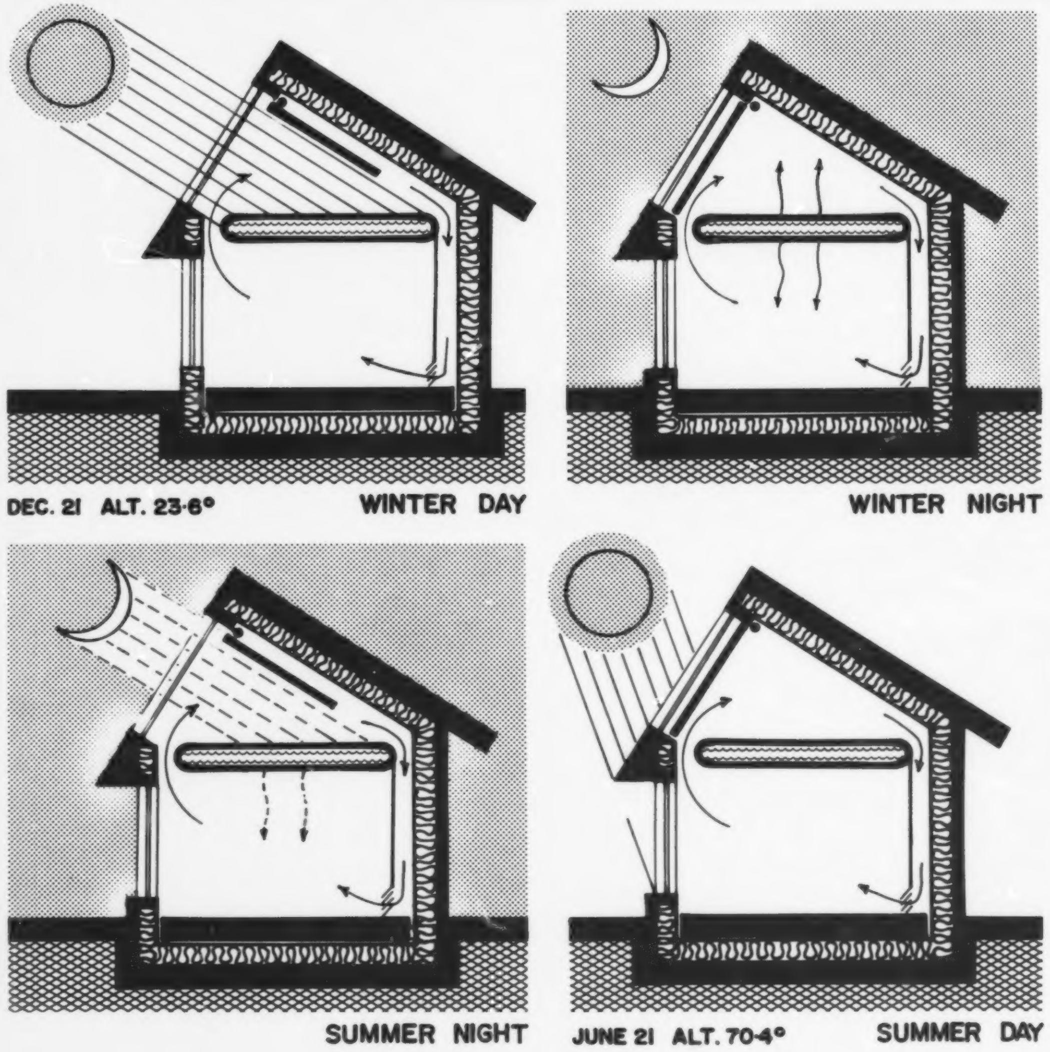
SUNSPACE SYSTEM

MASS ROOF SYSTEMS ARE ALSO CALLED ROOF PONDS .

THEY CONSIST OF A POND OF WATER ENCLOSED IN DARK PLASTIC WHICH IS PLACED UPON METAL CEILINGS. A SHUTTER SYSTEM IS INSTALLED ABOVE.

IN THE WINTER, THE SHUTTERS ARE OPENED DURING THE DAY TO ABSORB SOLAR RADIATION WITHIN THE ROOF POND. AT NIGHT, THE SHUTTERS ARE CLOSED AND THE STORED ENERGY IS RADIATED DOWNWARD WITHIN THE HEATED SPACE.

IN THE SUMMER, THE SHUTTERS ARE OPENED AT NIGHT AND THE ROOF POND IS COOLED. DURING THE DAYTIME, THE SHUTTERS ARE CLOSED AND THE POND ABSORBS HEAT FROM WITHIN THE HOUSE, KEEPING IT COOL



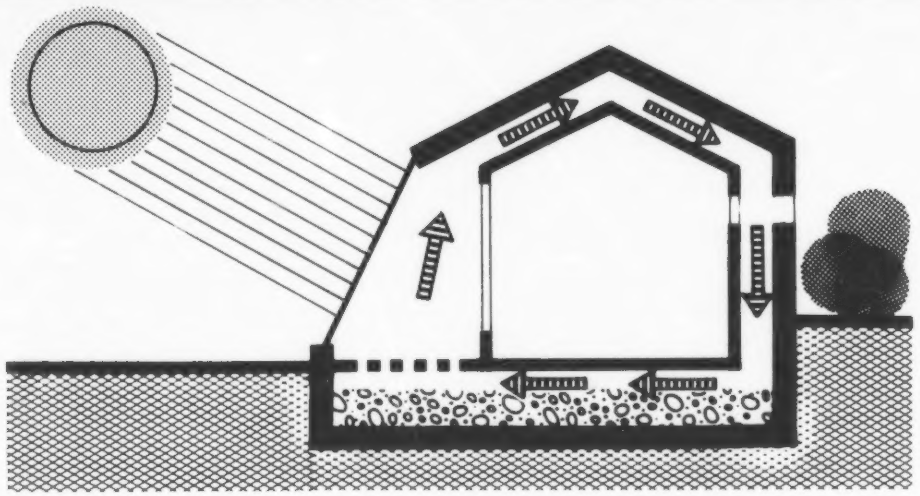
MASS ROOF

THE DOUBLE SHELL CONCEPT IS THE MOST SOPHISTICATED SOLUTION IN THE PASSIVE SOLAR APPROACH.

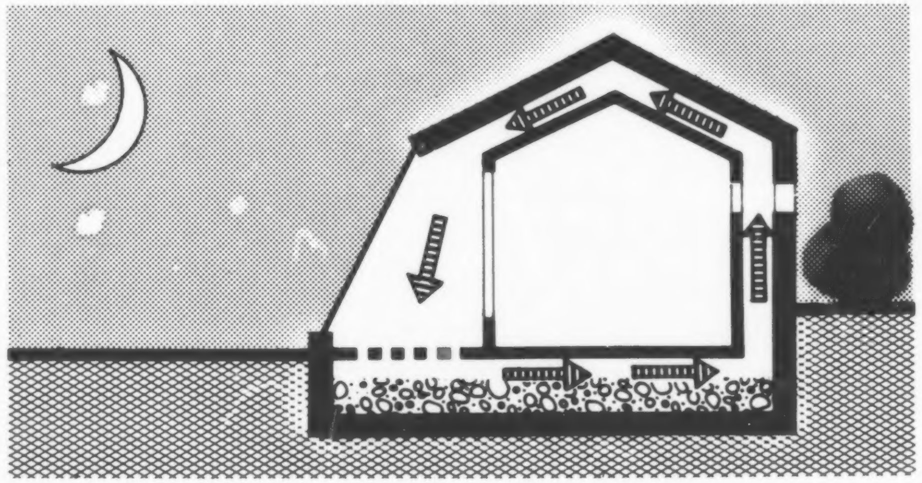
SOME OF THEM FUNCTION WITHOUT THE ASSISTANCE OF ANY MECHANICAL DEVICE SUCH AS FANS, BLOWERS, DAMPERS, MOBILE INSULATION ETC.

THIS CONCEPT HAS ATTRACTED THE ATTENTION OF MANY U.S. DESIGNERS AND BUILDERS. SEVERAL HOUSES ARE ALSO UNDER CONSTRUCTION IN ONTARIO. THEIR PERFORMANCE IS BEING CLOSELY MONITORED.

THE RESULTS, WHICH ARE COMING IN, ARE STARTLING.



DAY



NIGHT

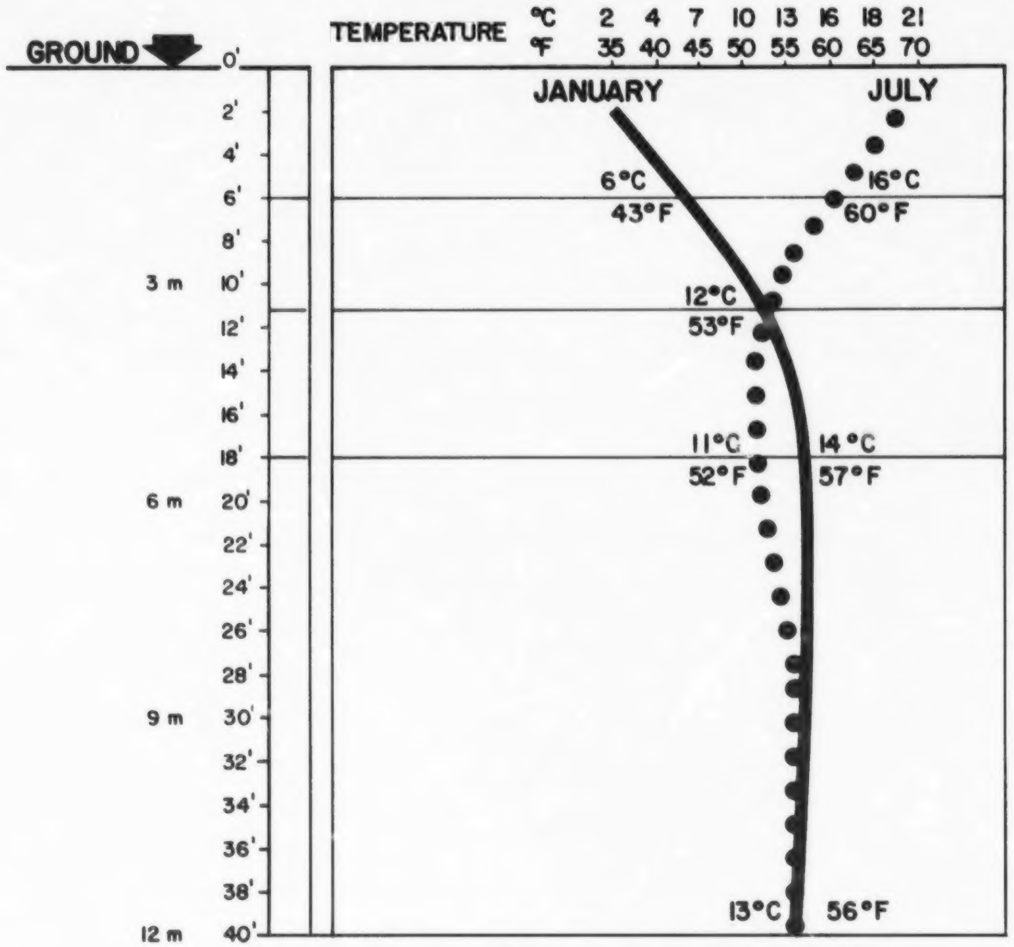
DOUBLE SHELL DESIGN CONCEPT

THOUSANDS OF EARTH-SHELTERED HOUSES HAVE ALREADY BEEN BUILT IN THE U.S.A. ENTHUSIAMS FOR THEM IS SPREADING ACROSS THE BORDER.

ALTHOUGH AN EARTH-SHELTERED HOUSE MAY BE CONSIDERED AN EXTREME SOLUTION TO THE PROBLEM OF AN ENERGY-EFFICIENT HOUSE, THOSE WHO HAVE HAD THE OPPORTUNITY TO VISIT ONE ARE USUALLY ASTONISHED BY THE AMOUNT OF DAYLIGHT, SPATIAL QUALITY AND SUPERIOR THERMAL PERFORMANCE THEY OFFER.

MANY SKEPTICS HAVE BEEN CONVERTED TO VIGOROUS PROMOTERS.

SOIL INSULATION PROPERTIES PEND ON A NUMBER OF FACTORS: PHYSICAL AND CHEMICAL COMPOSITION, BIOLOGICAL, CONTENT, MOISTURE, NATURE OF THE SURFACE, ETC. IN THE HAMILTON AREA, IT REQUIRES ABOUT THREE TO THREE AND HALF FEET OF EARTH COVER TO PREVENT WATER FROM FREEZING. EARTH'S MOST FASCINATING PROPERTY IS ITS LAZY RESPONSE TO TEMPERATURE CHANGES. AS ILLUSTRATED BY THE DIAGRAM, AT A DEPTH OF 18' ANNUAL EXTREMES OF HEAT AND COLD ARE EXACTLY OPPOSITE TO THE SITUATION ON THE SURFACE. THERE ARE MANY WAYS OF TAKING ADVANTAGE OF THIS PECULIARITY. ONE METHOD IS THE HEAT PUMP.

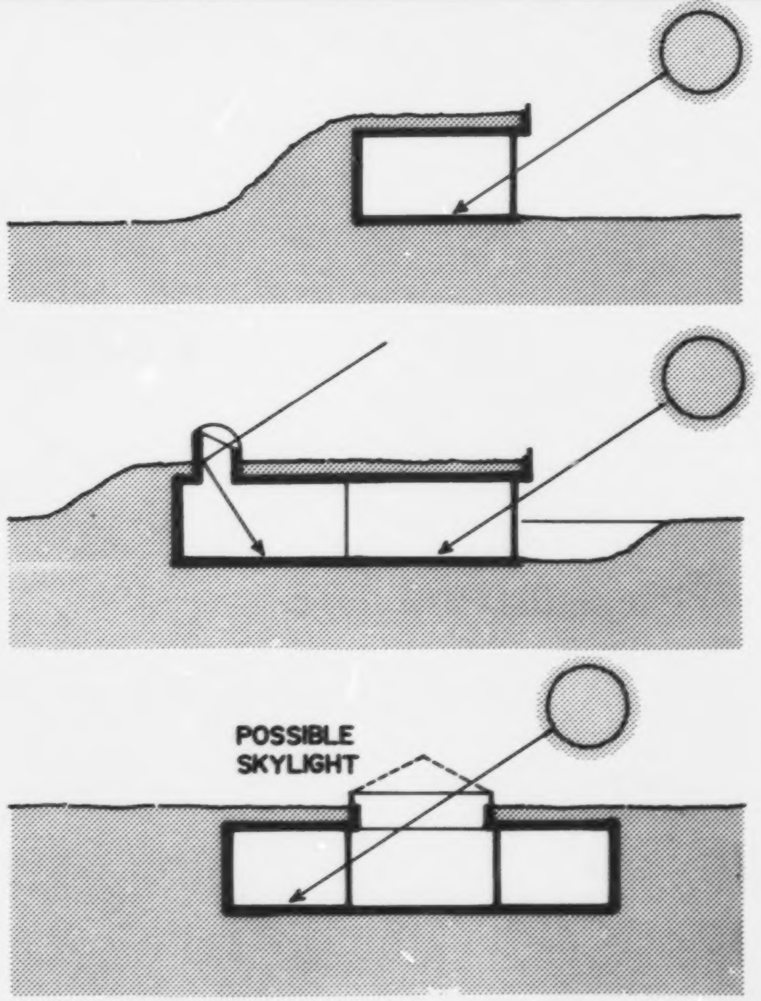


MEASUREMENTS OF THE TEMPERATURE DISTRIBUTION AT THE CAMPUS OF McMASTER UNIVERSITY, HAMILTON, ONTARIO FROM OCTOBER 1964 TO SEPTEMBER 1966.

VARIATION OF SOIL TEMPERATURE

FLAT SITE

- ABOVE GROUND
- SEMI UNDERGROUND
- FULLY UNDERGROUND



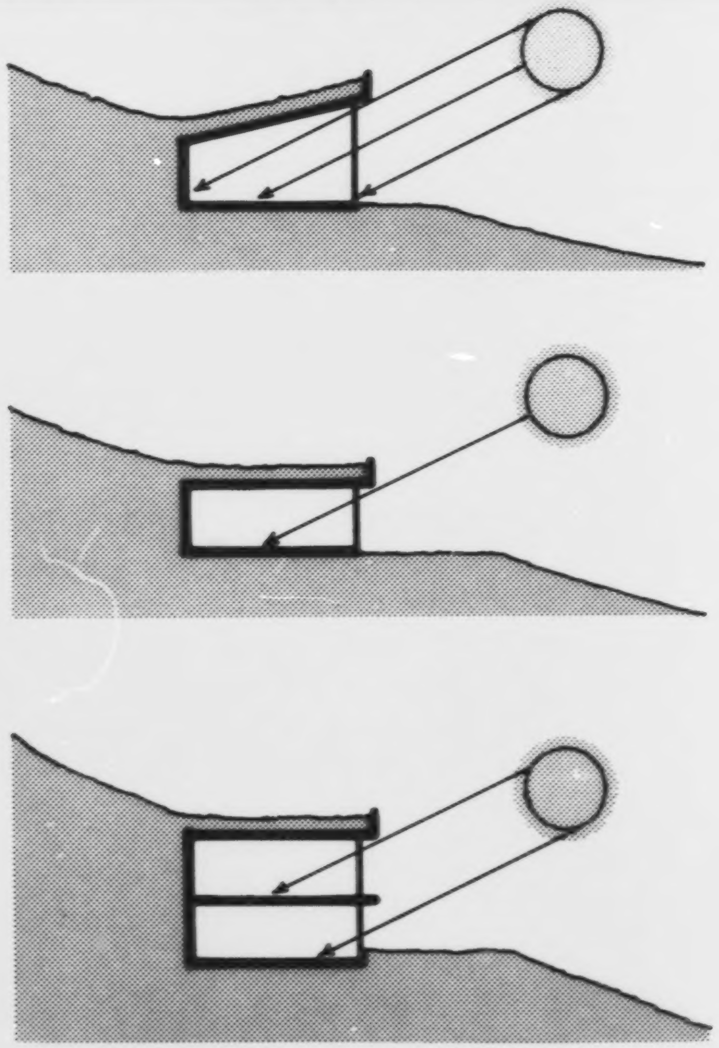
EARTH SHELTERED HOUSES

SLOPING SITE

• SLOPING ROOF

• ONE FLOOR

• TWO FLOORS



EARTH SHELTERED HOUSES

DURING THE LAST FEW DECADES, WE LEARNED TO CONSIDER THE DIFFERENCES BETWEEN INDIVIDUAL PARCELS OF LAND OF THE SAME SIZE TO BE MARGINAL. THE BULLDOZER AND OVERSIZED HEATING AND COOLING SYSTEMS WERE VERY SUCCESSFUL IN THE EQUALIZATION PROCESS. WHILE SOME AREAS IN THE CURRENT SUBDIVISION LAYOUT MAY BE SUITABLE FOR THE PASSIVE SOLAR APPROACH, THE OVERALL PLANNING PHILOSOPHY IS ALIEN TO ENERGY CONSERVATION. THE PASSIVE SOLAR APPROACH TAKES ADVANTAGE OF THE TOPOGRAPHICAL AND OTHER UNIQUE FEATURES OF AN INDIVIDUAL SITE. THE STREET LAYOUT, SETBACKS AND HEIGHT LIMITS ARE PART OF A SINGLE SYSTEM WHICH ENSURES MAXIMUM SOLAR EXPOSURE. (A GUARANTEED "SUN WINDOW" FOR EVERY HOUSE.)

THUS, THE MOST OBVIOUS DIFFERENCE BETWEEN A CONVENTIONAL SYSTEM AND A PASSIVE SOLAR APPROACH IS IN THE SHAPE AND SIZE OF THE DEVELOPABLE SPACE - THE ENVELOPE.

A

STREET ORIENTATION : NORTH–SOUTH
LOT AND HOUSE ORIENTATION :
FACING EAST AND FACING WEST

THE SUN IS ONLY AVAILABLE IN THE MORNING OR IN THE EVENING.

EACH HOUSE SHADOWS ANOTHER HOUSE.

DISADVANTAGES :

- ELIMINATES THE POSSIBILITY OF DESIGNING A PASSIVE HEATING SYSTEM.
- MAKES IMPOSSIBLE THE INSTALLATION OF SOLAR COLLECTORS IN THE FUTURE.
- PRIVATE GREEN SPACE IS EXPOSED TO THE SUN FOR HALF A DAY ONLY.

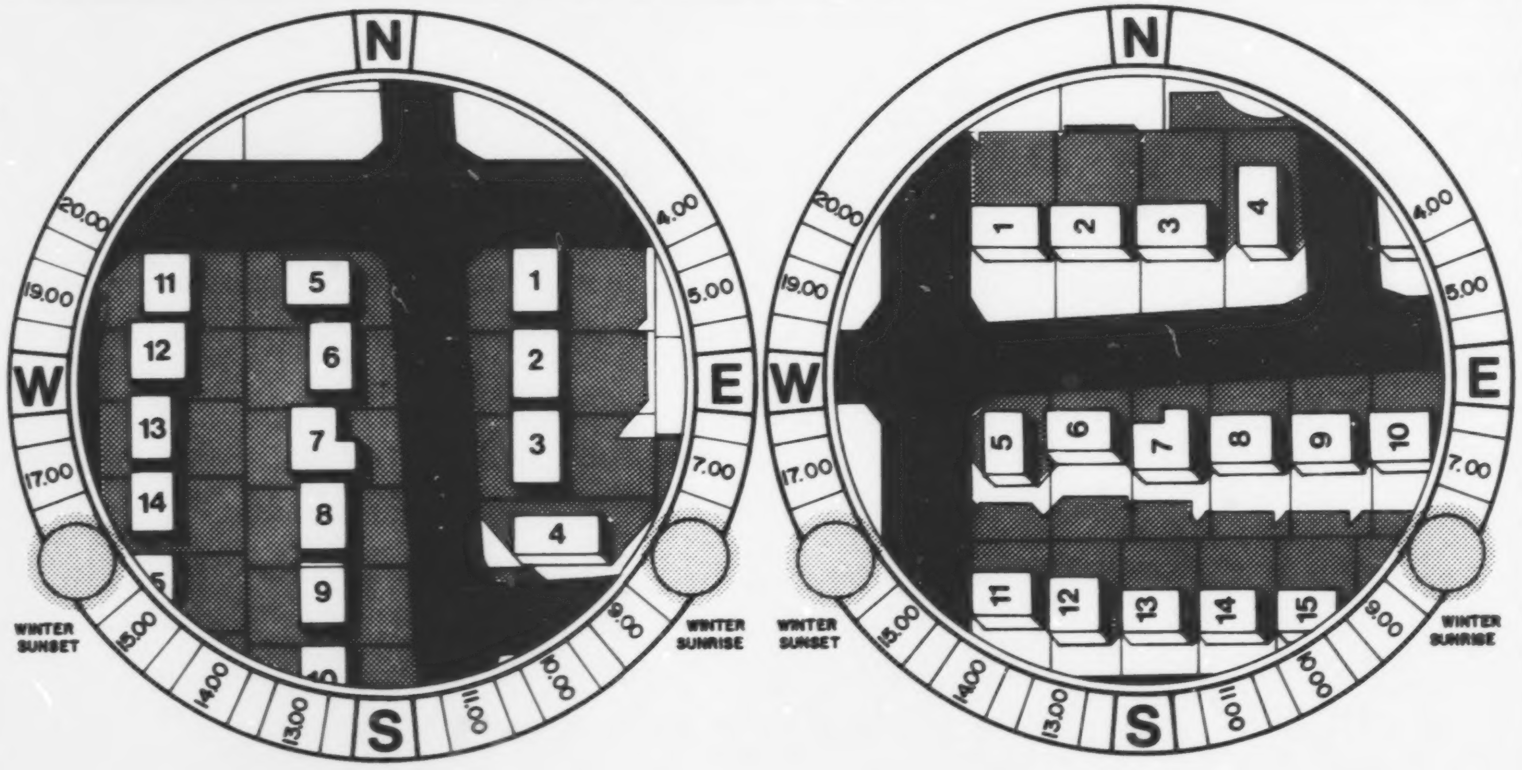
B

THIS IS THE IDENTICAL SUBDIVISION TURNED 90°.

STREET ORIENTATION : EAST – WEST
LOT AND HOUSE ORIENTATION :
FACING NORTH AND FACING SOUTH

ADVANTAGES :

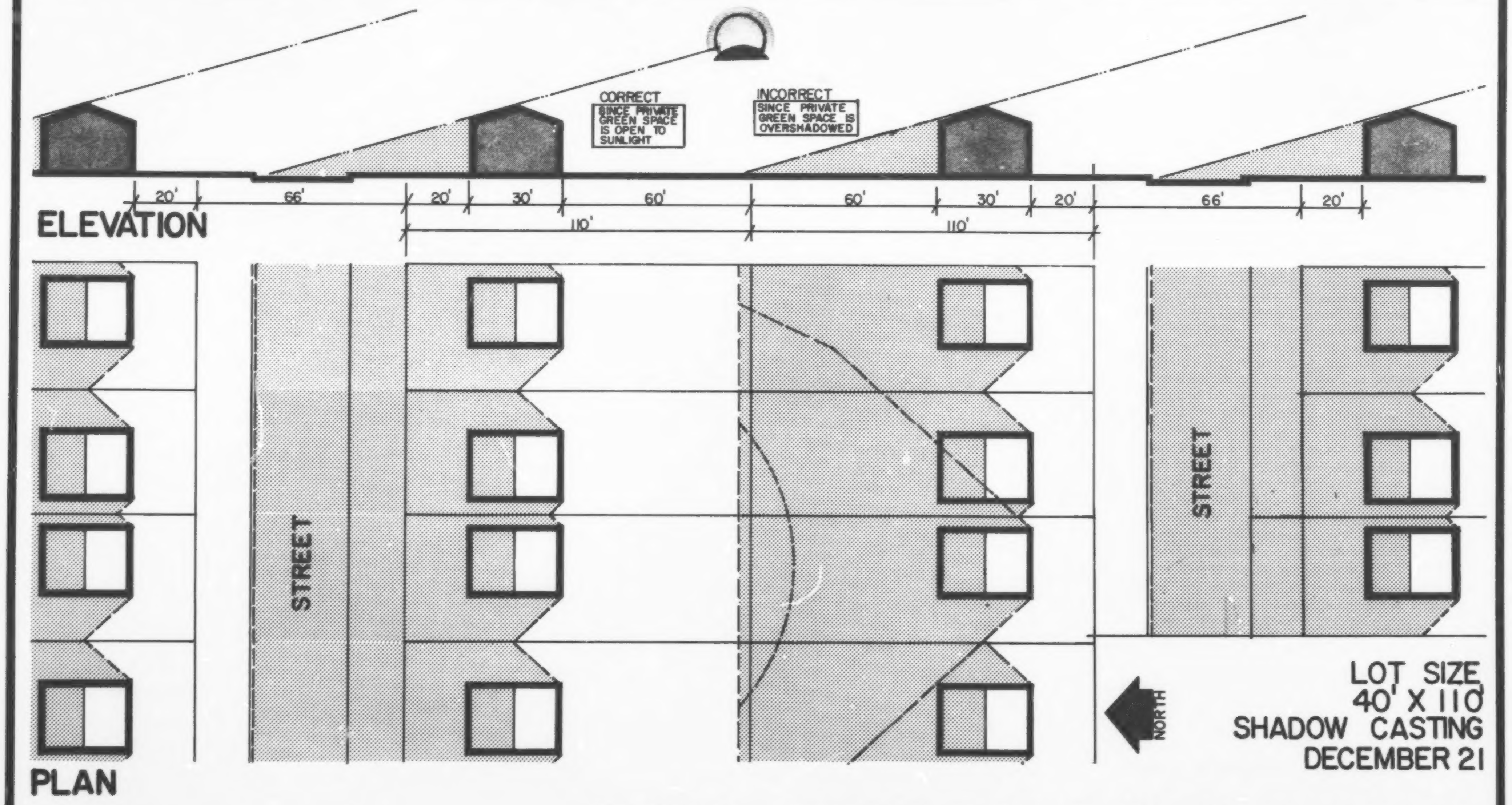
- CONDUCIVE TO THE UTILIZATION OF A PASSIVE SOLAR HEATING SYSTEM.
- POSSIBILITY OF INSTALLATION OF SOLAR COLLECTORS FOR THE FUTURE.
- PRIVATE GREEN SPACE EXPOSED TO THE SUN ALMOST THE WHOLE DAY.



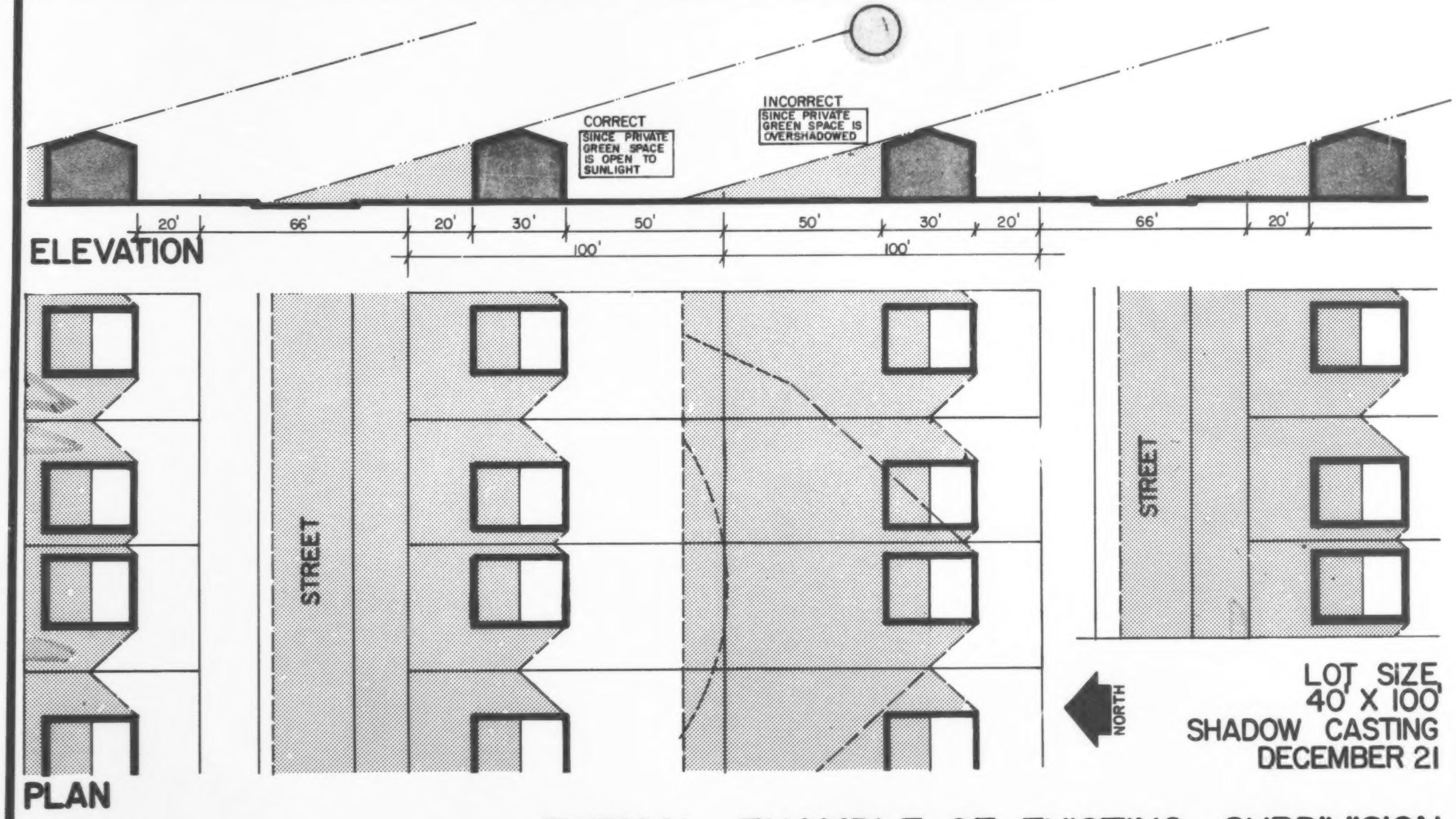
A B

CONCLUSION | SIMPLE 90 DEGREES TURN OF THE SAME SUBDIVISION LAYOUT LEADS TO A HIGH SOLAR ENERGY YIELD AND ENERGY EFFICIENCY

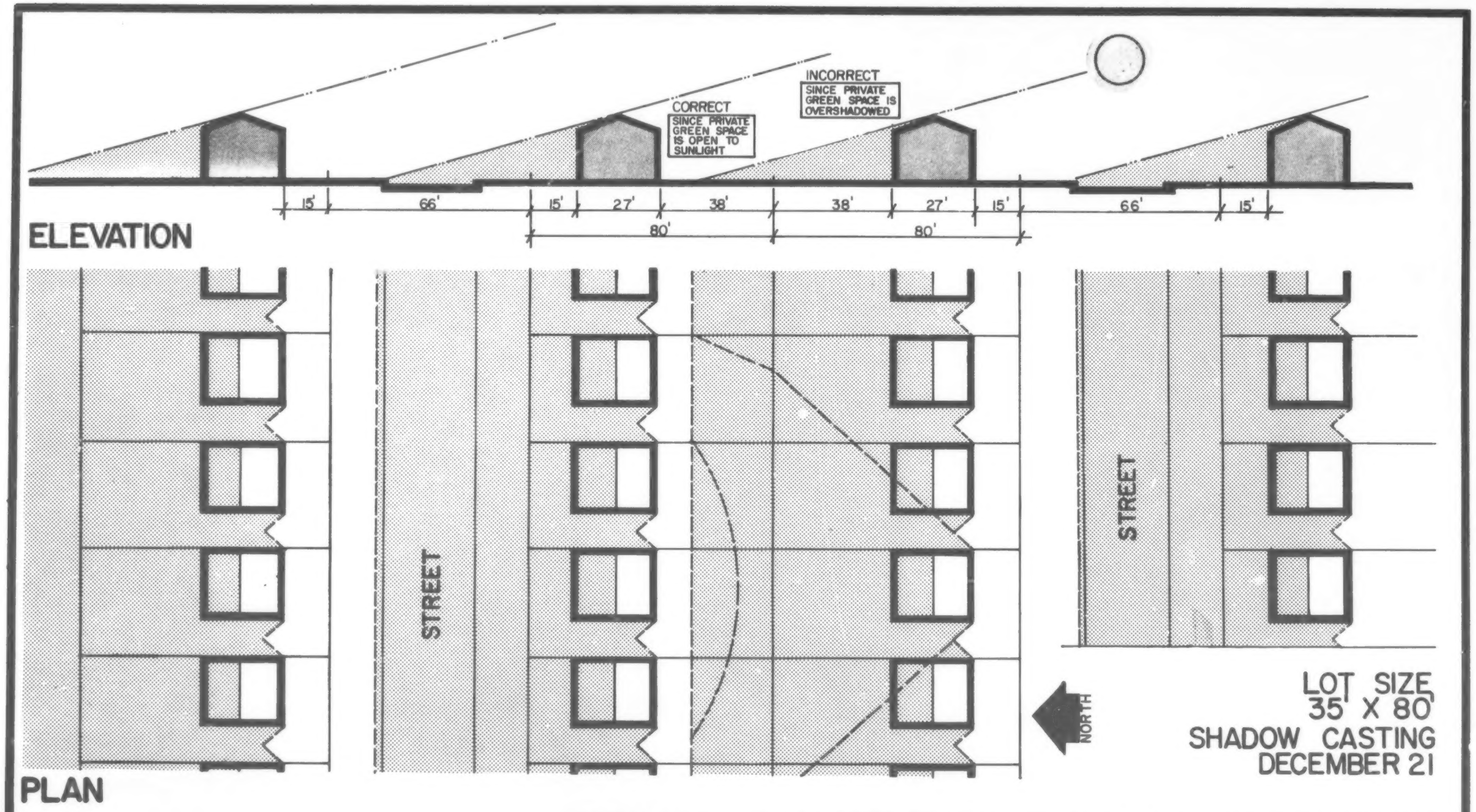
SUBDIVISION ORIENTATION AND SHADOW CASTING



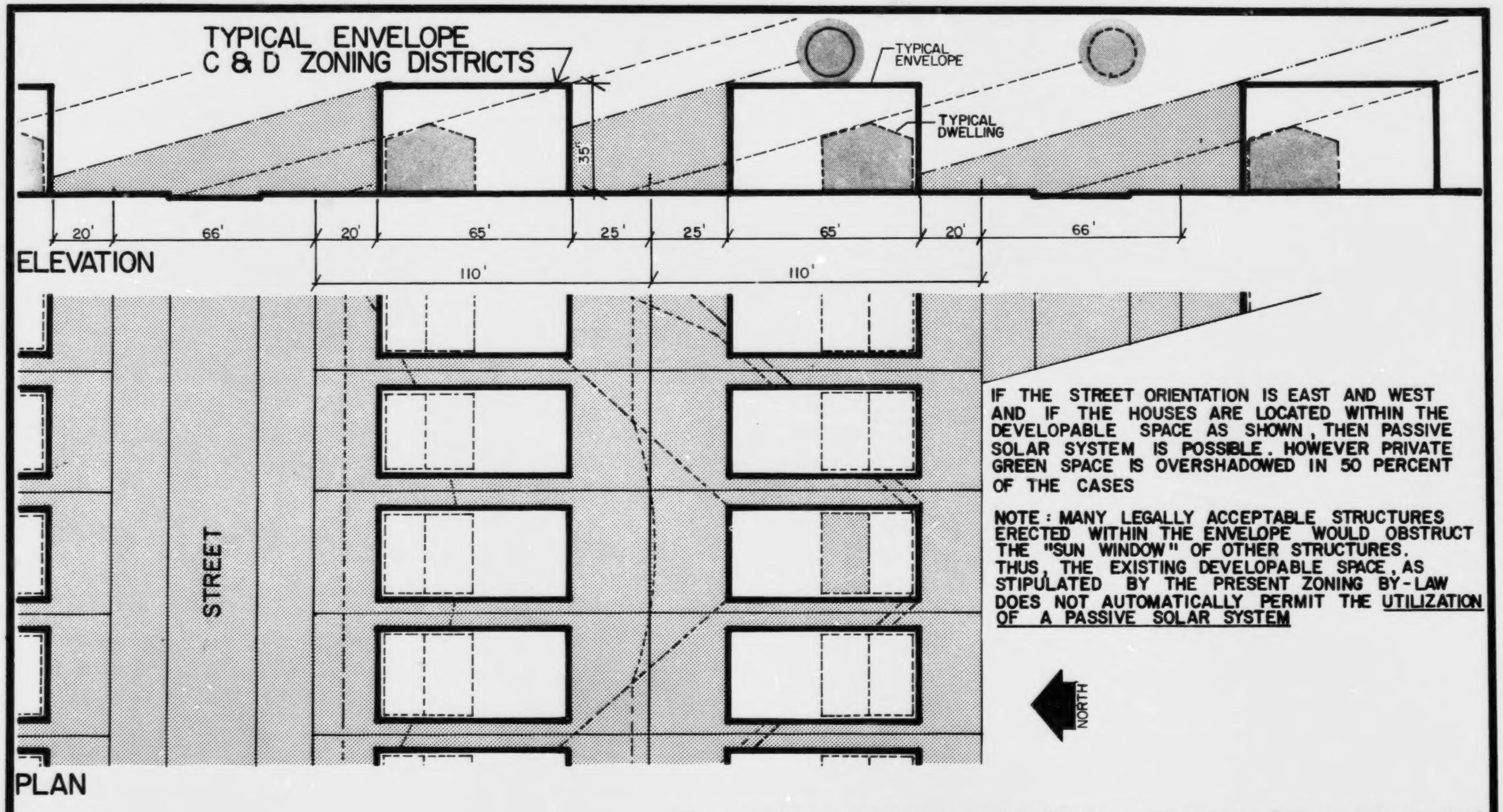
TYPICAL EXAMPLE OF EXISTING SUBDIVISION



TYPICAL EXAMPLE OF EXISTING SUBDIVISION



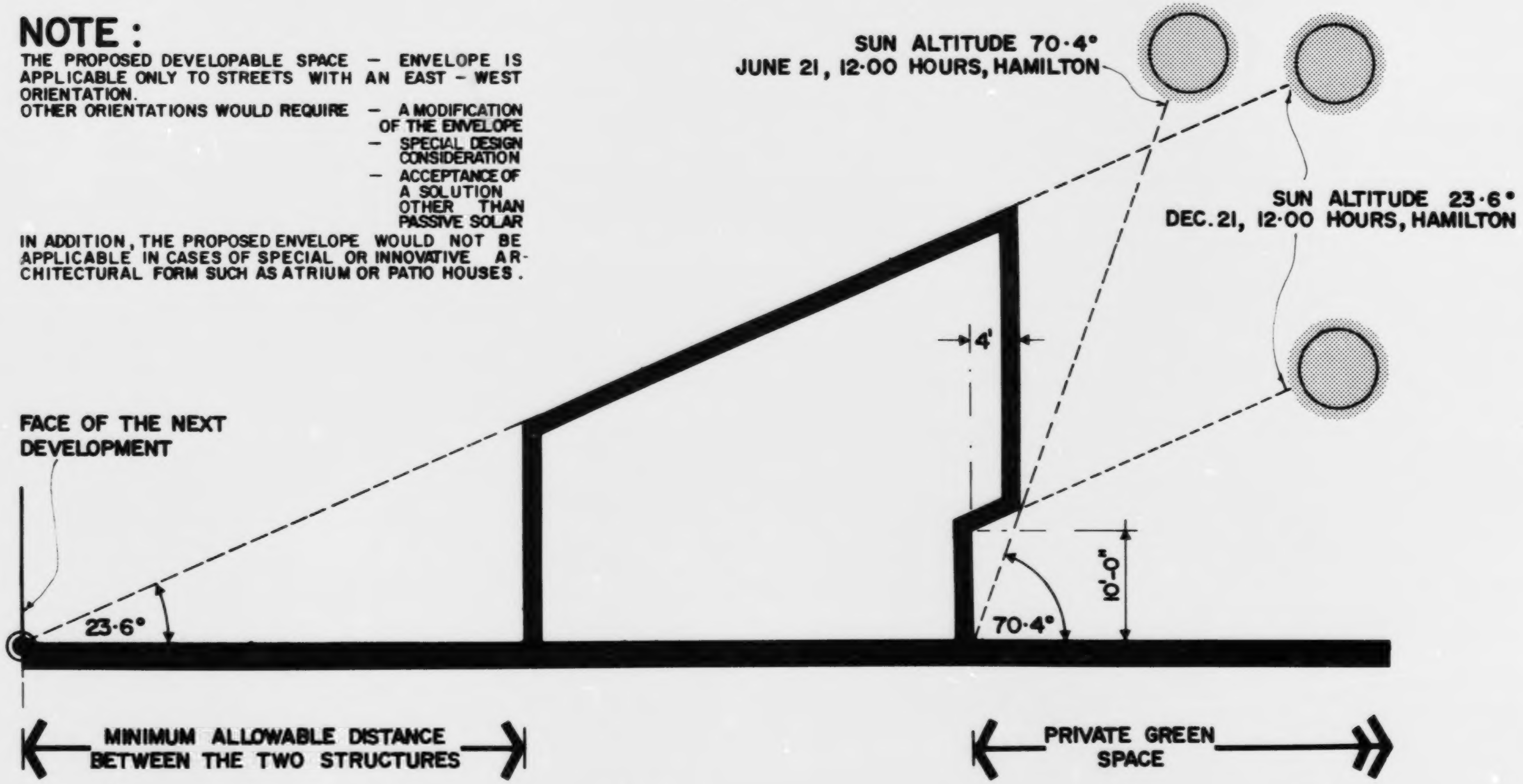
TYPICAL EXAMPLE OF EXISTING SUBDIVISION



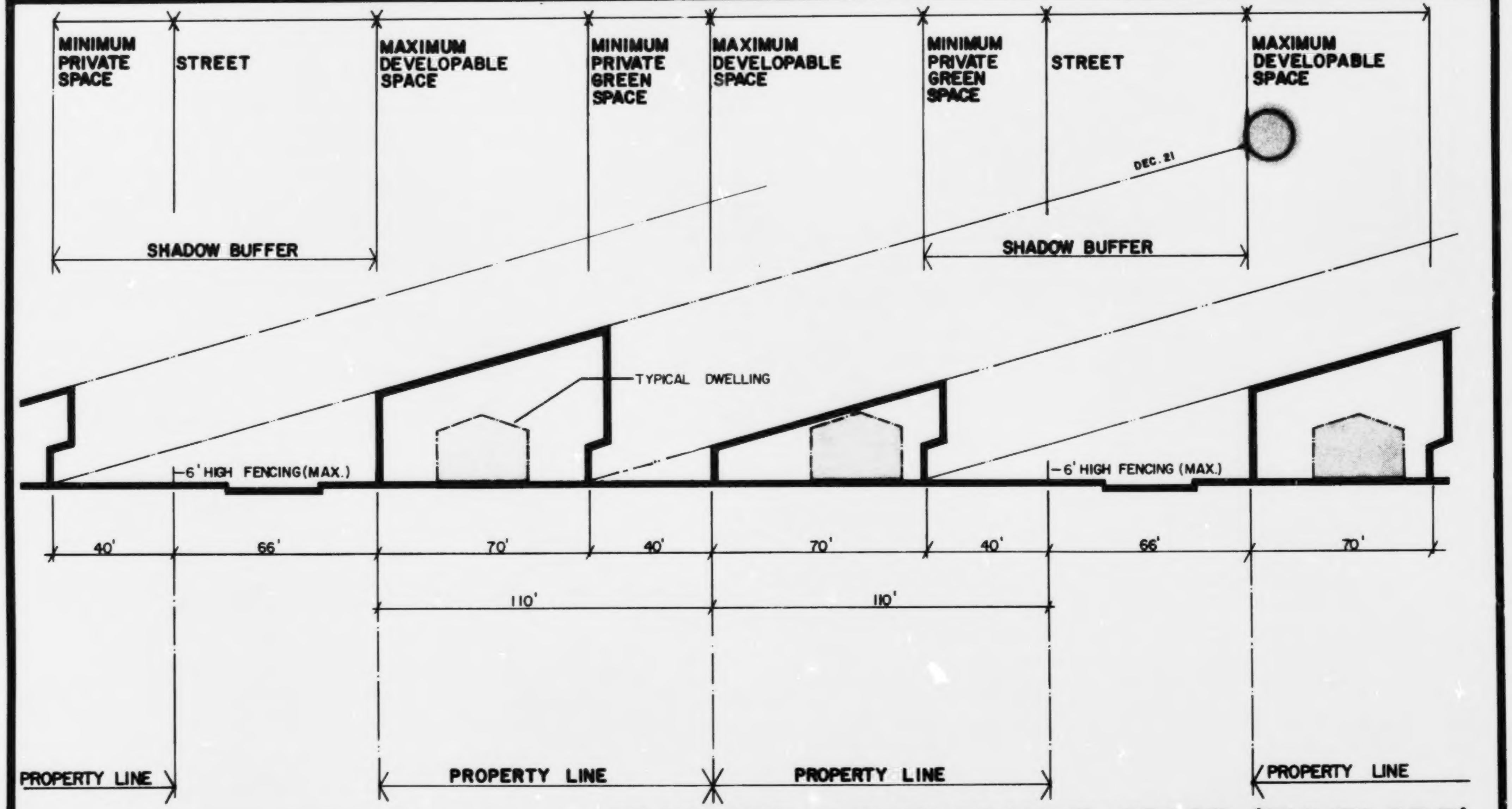
IF THE STREET ORIENTATION IS EAST AND WEST AND IF THE HOUSES ARE LOCATED WITHIN THE DEVELOPABLE SPACE AS SHOWN, THEN PASSIVE SOLAR SYSTEM IS POSSIBLE. HOWEVER PRIVATE GREEN SPACE IS OVERSHADOWED IN 50 PERCENT OF THE CASES

NOTE: MANY LEGALLY ACCEPTABLE STRUCTURES ERECTED WITHIN THE ENVELOPE WOULD OBSTRUCT THE "SUN WINDOW" OF OTHER STRUCTURES. THUS, THE EXISTING DEVELOPABLE SPACE, AS STIPULATED BY THE PRESENT ZONING BY-LAW DOES NOT AUTOMATICALLY PERMIT THE UTILIZATION OF A PASSIVE SOLAR SYSTEM

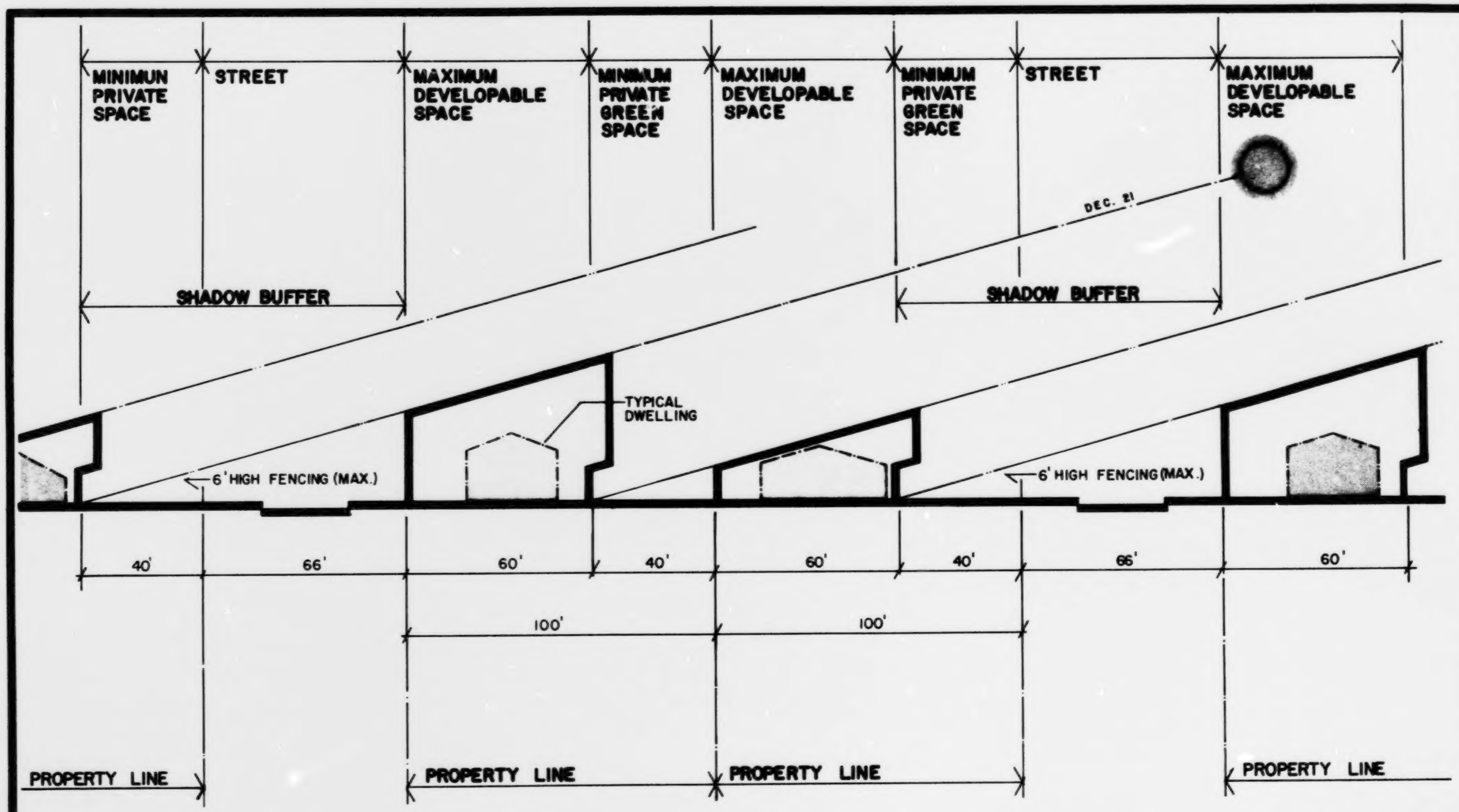
EXISTING DEVELOPABLE SPACE (ENVELOPE)



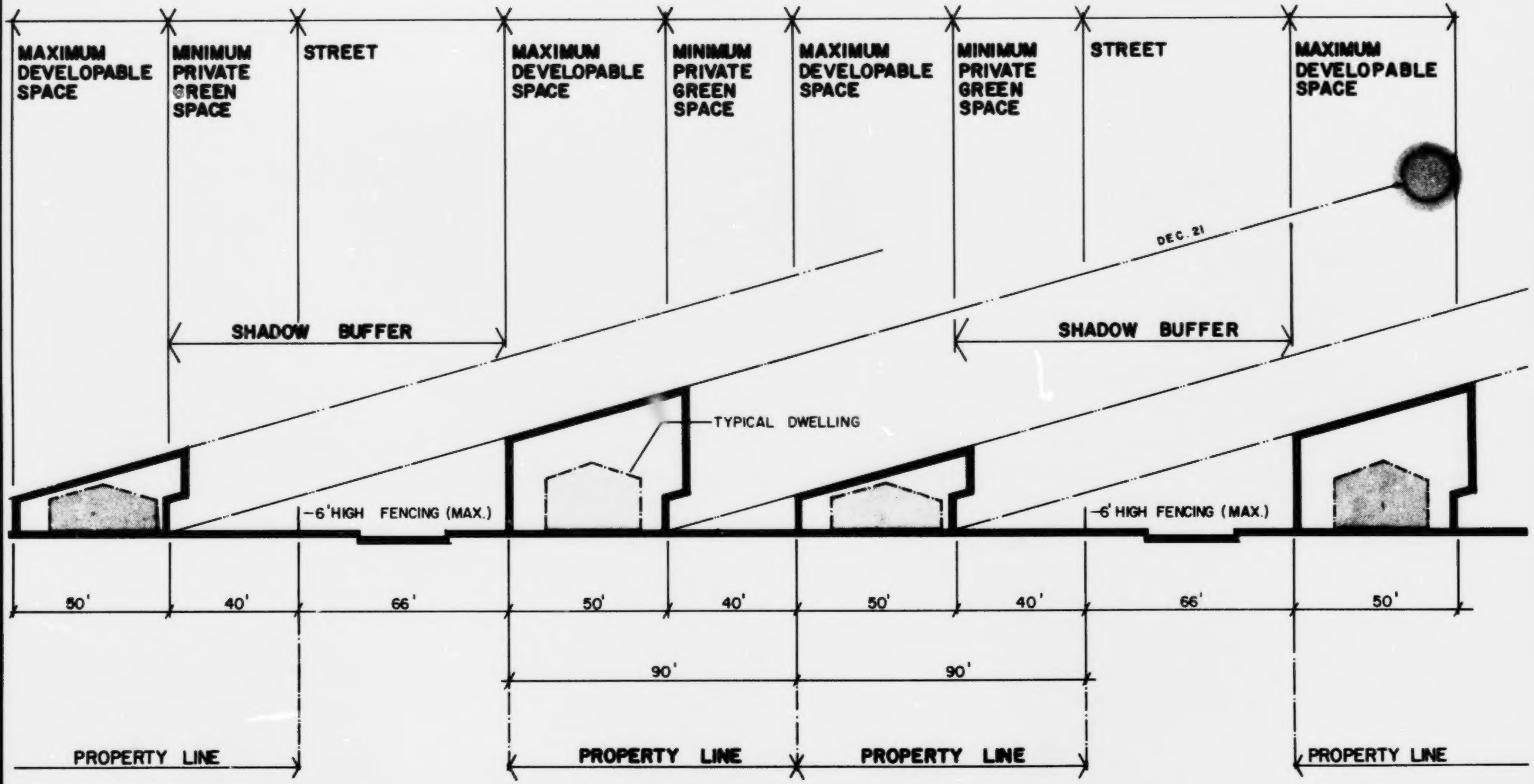
DERIVATION OF THE PROPOSED DEVELOPABLE SPACE (ENVELOPE)



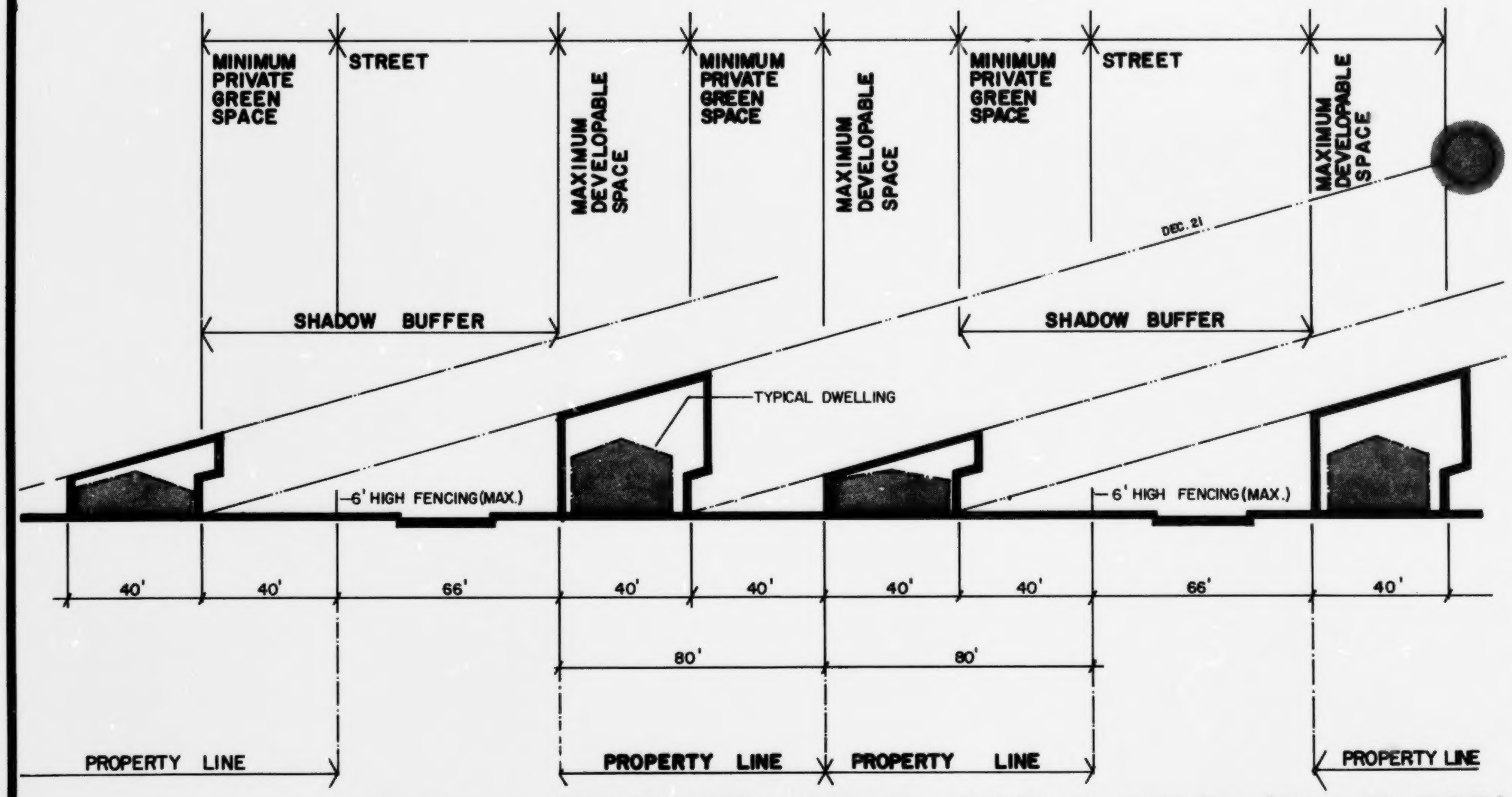
110' LOT - PROPOSED DEVELOPABLE SPACE (ENVELOPE)



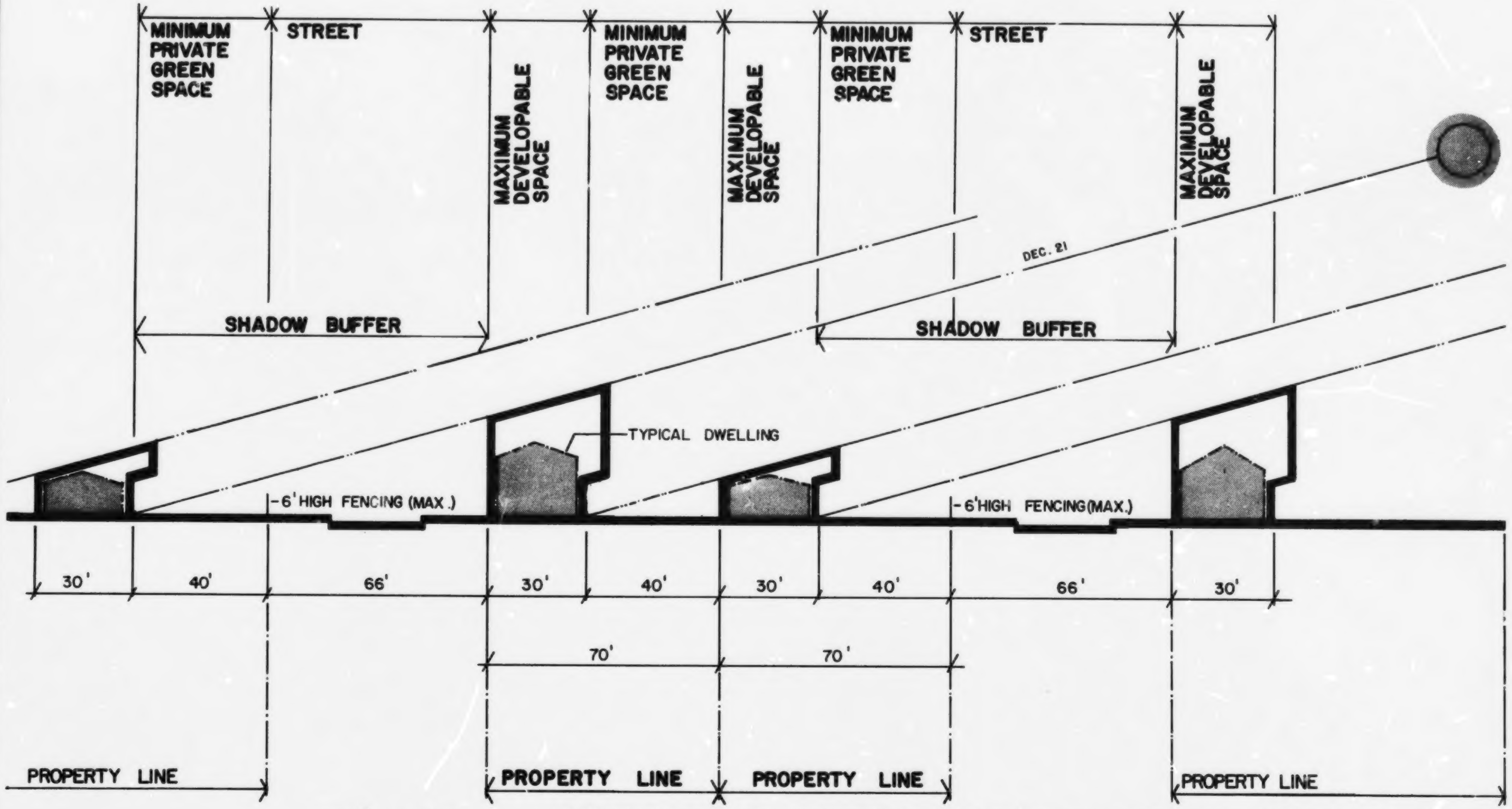
100' LOT - PROPOSED DEVELOPABLE SPACE (ENVELOPE)



90' LOT - PROPOSED DEVELOPABLE SPACE (ENVELOPE)



80' LOT - PROPOSED DEVELOPABLE SPACE (ENVELOPE)



70' LOT - PROPOSED DEVELOPABLE SPACE (ENVELOPE)

THE DEVELOPMENT AND REFINEMENT OF ARCHITECTURAL FORMS, AS WELL AS THE NEW GENERATION OF HIGHLY-SOPHISTICATED MECHANICAL DEVICES, SUCH AS COMPUTER-OPERATED THERMAL SYSTEMS, HEAT RECOVERY AND STORAGE SYSTEMS, HEAT PUMPS, DISTRICT HEATING, ETC., ARE COMPLIMENTARY TO THE PASSIVE APPROACH.

SOME OF THESE IDEAS ARE DISCUSSED ON THE FOLLOWING PAGES.

OTHER CONSIDERATIONS

WITH MORE PRESSURE FOR AN EFFICIENT UTILIZATION OF LAND, THE NEED FOR HOUSE DESIGN INNOVATION WILL GROW. HOWEVER, NEW FORMS OF ARCHITECTURAL DESIGN DO NOT NECESSARILY REQUIRE A GENUINE INVENTION. WE CAN BORROW OR ADAPT OLD CONCEPTS WHICH SUIT OUR PRESENT NEEDS AND REQUIREMENTS. ONE VERY OLD AND VERY ATTRACTIVE DESIGN CONCEPT WHICH WOULD FIT OUR ENERGY EFFICIENT "HIGH DENSITY/LOW RISE" REQUIREMENTS IS THE ATRIUM HOUSE (ALSO CALLED THE "SPANISH COURT HOUSE" OR "ROMAN COURT HOUSE"). THIS TYPE OF HOUSE CAN BE LOCATED ON AN INDIVIDUAL LOT WITH ALL SETBACKS AS REQUIRED BY CURRENT PRACTICE. BUT, BY VIRTUE OF ITS LAYOUT, THE MINIMUM SIZE OF THE LOT REQUIRED COULD BE AS SMALL AS THE SIZE OF THE HOUSE. A TRUE FOUR-SIDED ZERO LOT LINE IDEA.

SOME DEVELOPMENTS WHICH FULLY UTILIZE THE ATRIUM DESIGN CONCEPT ARE ACHIEVING DENSITIES OF UP TO 200 PERSONS PER ACRE. INTERESTINGLY, NONE OF THE STRUCTURES ARE MORE THAN TWO STORIES HIGH, YET THEY OFFER THE UTMOST IN PRIVACY AND PROVIDE A FAMILY LIVING ENVIRONMENT SUPERIOR TO THAT IN ANY CONVENTIONAL SUBDIVISION DEVELOPMENT.

THE COMBINATION OF AN ATRIUM HOUSE WITH A SPLIT-LEVEL CONCEPT IS CALLED THE PATIO HOUSE. IT OFFERS FURTHER ADVANTAGES. IN ADDITION TO THE INTERIOR COURT, THIS DESIGN CONCEPT ALSO UTILIZES THE LOWER PART OF THE BUILDING FOR A PATIO OR FOR A ROOF GARDEN. THE "PATIO HOUSE" CONCEPT ALSO OFFERS THE UTILIZATION OF ATTACHABLE GREENHOUSES AND WINTER GARDENS AND MAKES IT POSSIBLE TO DESIGN A RELATIVELY SIMPLE PERMANENT OR MOBILE GLASS ROOF OVER THE ATRIUM. THE PRIVATE OPEN SPACE OR "GREEN ROOM" IS SUITABLE FOR ALMOST ANY FORM OF FAMILY RECREATION VIRTUALLY THROUGHOUT THE YEAR.

THE ATRIUM AND THE PATIO GARDEN COMPRISES INNER PRIVACY, AND SERVES, IN FACT, AS THE PSYCHOLOGICAL CENTRE OF THE HOME. THUS, THIS DESIGN CONCEPT PROVIDES A SUPERIOR FAMILY ENVIRONMENT AND LIVING QUALITY UNMATCHED BY ANY PRESENTLY-BUILT HOUSE FORM.

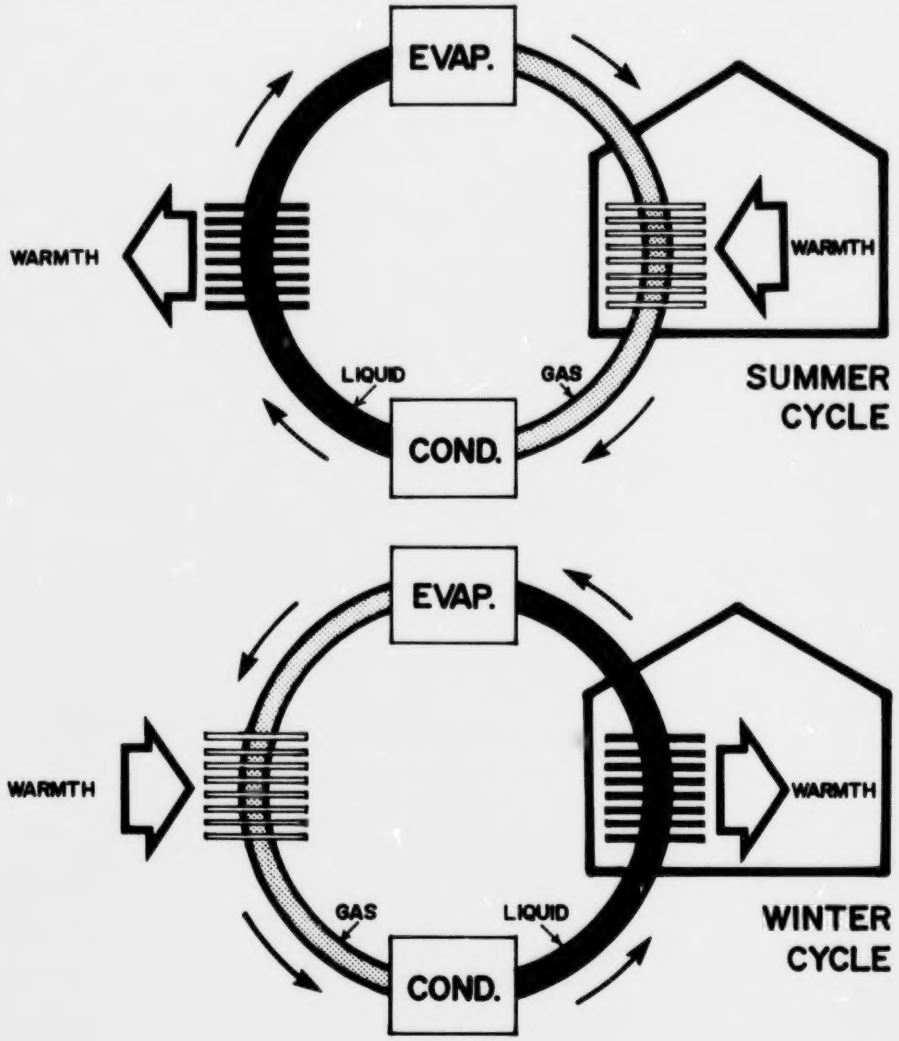
ATRIUM AND PATIO HOUSES ARE VERY ENERGY EFFICIENT.

A HEAT PUMP IS A DEVICE WHICH TRANSFERS THERMAL ENERGY OR HEAT FROM A COOLER REGION TO A WARMER ONE. THE DIRECTION OF ENERGY TRANSFER IS CONTRARY TO THE NORMAL FLOW. HEAT NATURALLY FLOWS FROM A WARMER REGION TO A COOLER REGION.

A REFRIGERATOR ACTS AS A HEAT PUMP. THE RADIATOR AT THE BACK OF THE REFRIGERATOR IS WARM. THIS IS THE HEAT EXTRACTED FROM THE INTERIOR OF THE FRIDGE. A HEAT PUMP IS SIMPLY A REFRIGERATOR WHICH CAN OPERATE IN "TWO DIRECTIONS, ENABLING THE SAME EQUIPMENT TO HEAT OR COOL A GIVEN SPACE."

DURING THE HEATING MODE, LOW TEMPERATURE (LIQUID) FREON IS PUMPED THROUGH THE EVAPORATOR WHERE IT ABSORBS HEAT FROM THE SOURCE, (AIR, WATER, EARTH), AND GASIFIES. IT IS THEN COMPRESSED TO A MODERATELY HIGH TEMPERATURE AND PRESSURE, AND FORCED THROUGH THE CONDENSOR WHERE IT IT RELEASES ITS HEAT TO THE ROOM AS IT RETURNS TO A LIQUID STATE TO BEGIN THE CYCLE AGAIN. A FAN BLOWING AIR OVER THE CONDENSOR CIRCULATES WARM AIR THROUGH THE ROOM. DURING THE COOLING MODE, THIS PROCESS IS REVERSED. THE ROOM BECOMES THE SOURCE FROM WHICH HEAT IS EXTRACTED AND THE OUTSIDE BECOMES THE SINK AREA. THE EVAPORATOR, OF COURSE, IS COLD AND THEREFORE THE FAN CIRCULATES COOL AIR.

AT PRESENT, HEAT PUMPS ARE NOT VERY EFFICIENT AT LOW OUTSIDE TEMPERATURES. SOME SYSTEMS EXTRACT HEAT FROM UNDERGROUND WATER OR SOIL. HEAT PUMPS CAN ALSO BE COMBINED WITH SOLAR COLLECTORS. GENERALLY HEAT PUMPS ARE VERY PROMISING RESIDENTIAL HEAT SYSTEMS.



HEAT PUMP – COOLING & HEATING CYCLE

THE TIME WHEN EVERY ROOM IN THE HOUSE WAS HEATED BY ITS OWN STOVE IS STILL IN LIVING MEMORY. THE SAME HELD TRUE FOR EVERY ROOM OF A FLAT IN AN APARTMENT BUILDING AND EVERY OFFICE IN AN OFFICE BUILDING. IT WAS A GREAT LEAP FORWARD TOWARD EFFICIENCY TO PROVIDE HOUSES WITH CENTRAL HEATING SYSTEMS. THE FURNACE WENT INTO THE BASEMENT. IN LARGE BUILDINGS, IT WAS DELEGATED TO THE MECHANICAL ROOM. THE NEXT AND OBVIOUS STEP WAS TO BUILD A "SUPER FURNACE" FOR A GROUP OF HOUSES OR FOR A GROUP OF BUILDINGS. THE INNOVATION WAS CALLED "DISTRICT HEATING". A DISTRICT HEATING SYSTEM CAN BE FED BY ANY KNOWN FUEL. THIS INCLUDES HARD SOLAR AND NUCLEAR SYSTEMS. ALSO, IT CAN FUNCTION AS A DISTRICT HEAT EXCHANGER TO UTILIZE EXCESS HEAT FROM INDUSTRIAL AND COMMERCIAL ESTABLISHMENTS WHICH OTHERWISE WOULD BE DUMPED.

THE DISTRICT HEATING SYSTEM WAS VERY POPULAR BEFORE THE SECOND WORLD WAR. LATER, IN THE ERA OF (PRACTICALLY) FREE ENERGY, A CALL FOR EFFICIENCY WAS CONSIDERED TO BE MEANINGLESS OR EVEN ECCENTRIC. THE FURTHER DEVELOPMENT AND USE OF DISTRICT HEATING SYSTEMS CAME TO A HALT.

DISTRICT HEATING

AT PRESENT, WE ARE EXPERIENCING A RENEWED INTEREST IN DISTRICT HEATING. IT HAS TO BE UNDERSTOOD THAT THE ECONOMY AND EFFICIENCY OF THIS SYSTEM IS RELATED TO THE DISTANCE OVER WHICH THE HEAT HAS TO BE CARRIED. THE FURNACE IN OUR BASEMENT WOULD GO MAD IF EVERY ROOM OF OUR HOUSE WERE TO BE BUILT AS A SEPARATE STRUCTURE, YARDS AND YARDS AWAY. THE CHALLENGE OF DESIGNING RESIDENTIAL DEVELOPMENTS HEATED BY DISTRICT HEATING SYSTEMS LIES IN PHYSICAL PROXIMITIES AND COMPACTNESS. ALTHOUGH WE HAVE TO DEAL WITH HIGHER DENSITIES, QUALITY AND SPATIAL COMFORT MUST NOT BE SACRIFICED. AN INNOVATIVE ARCHITECTURAL FORM CAN DO THE TRICK.

A SHADOW TEMPLATE SET IS THE SIMPLEST TOOL FOR DETERMINING THE SIZE AND DIRECTION OF SHADOWS CAST BY ANY NATURAL OR MAN-MADE OBJECT.

WITH NO SECTION DRAWING REQUIRED, THE SET CAN BE USED FOR:

1. THE DESIGN AND EVALUATION OF DEVELOPMENT PROPOSALS, PLANS, LANDSCAPE AND ARCHITECTURAL DESIGNS, AND EVEN INTERIOR LAYOUTS. SHADOW TEMPLATES MAKE POSSIBLE A QUICK DETERMINATION OF SHADOWS AT 0900, 1000, 1200, 1400 AND 1500 HOURS ON THE 21ST DAY OF EVERY MONTH.
   FORMULA: SHADOW LENGTH = HEIGHT x COEFFICIENT
2. A DETERMINATION OF THE HEIGHT OF THE OBJECT, IF THE LENGTH OF THE SHADOW IS STIPULATED. THUS, WE CAN ARRIVE AT THE PERMISSIBLE HEIGHT OF ADJACENT STRUCTURES, TREES, THE HEIGHT AND SIZE OF AN OVERHANG, SUNSCREEN, AND ALSO ARRIVE AT THE DESIRABLE SIZE AND SHAPE OF WINDOWS, SKYLIGHTS AND OTHER OPENINGS AND ARCHITECTURAL FEATURES.
   FORMULA: HEIGHT = SHADOW LENGTH ÷ COEFFICIENT

SHADOW TEMPLATES

USE OF SHADOW TEMPLATE

TASK I:

FIND THE SHADOW OF A 10 FOOT HIGH POLE AT 09.00; 10.00; 12.00; 14.00; AND 15.00 HOURS.
DATE: DECEMBER 21 ST.
LATITUDE: 43 DEGREES NORTH (HAMILTON)
SLOPE: 0% (FLAT LAND)

STEP I:

SELECT THE CORRESPONDING TEMPLATE (I.E. DECEMBER 21)

STEP 2:

SEE FIGURE 2.

STEP 3:

SEE FIGURE 3.

STEP 4:

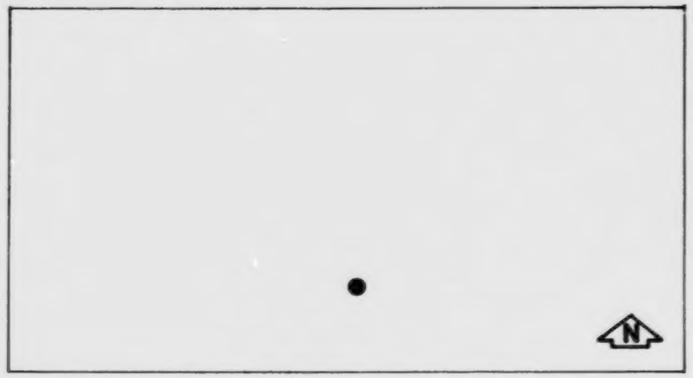
MULTIPLY THE HEIGHT OF THE OBJECT BY BY THE APPROPRIATE FIGURES ON THE TEMPLATE PROVIDED FOR EACH TIME PERIOD; FOR EXAMPLE:
AT 09.00 HOURS SHADOW OF OBJECT EQUALS HEIGHT OF OBJECT TIMES CONSTANT, (10' x 4.828' = 48.28 FEET)
THEREFORE, 48.28 IS THE LENGTH OF THE SHADOW CREATED BY THE OBJECT AT THAT PARTICULAR TIME (09.00 HOURS);
– REPEAT THIS PROCESS FOR ALL OTHER TIMES.

STEP 5:

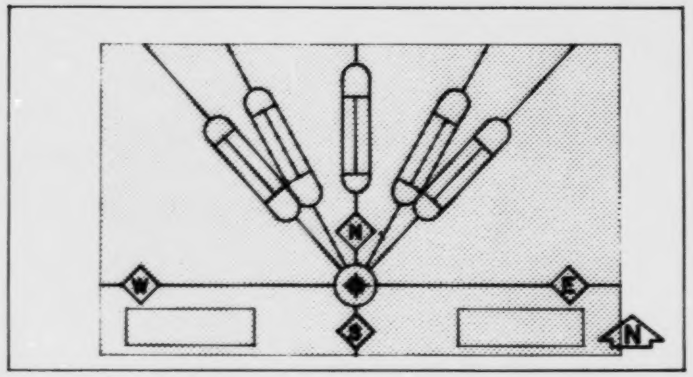
REMOVE THE TEMPLATE.

STEP 6:

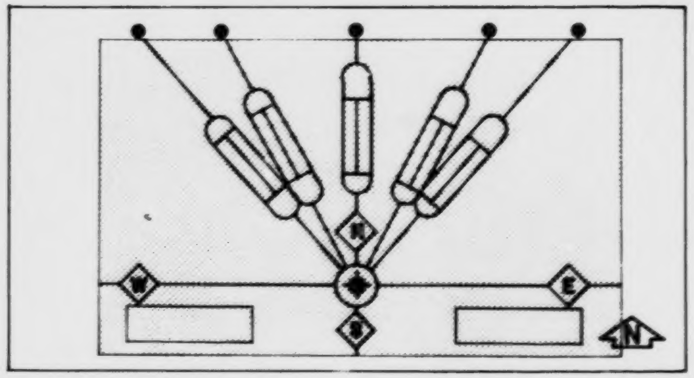
SEE FIGURE 4.



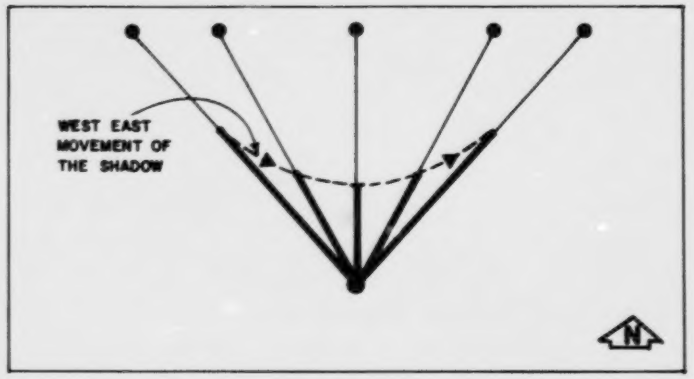
1. PLAN OF 10 FOOT POLE.



2. OVERLAY THE CENTRE OF THE CROSS IN THE CIRCLE ON THE CORRESPONDING TEMPLATE ONTO THE CENTRE OF THE OBJECT (I.E. 10 FOOT POLE). MAKE SURE THE POSITION OF THE NORTH POINT OF THE PLAN COINCIDES WITH THE NORTH POINT OF THE TEMPLATE.

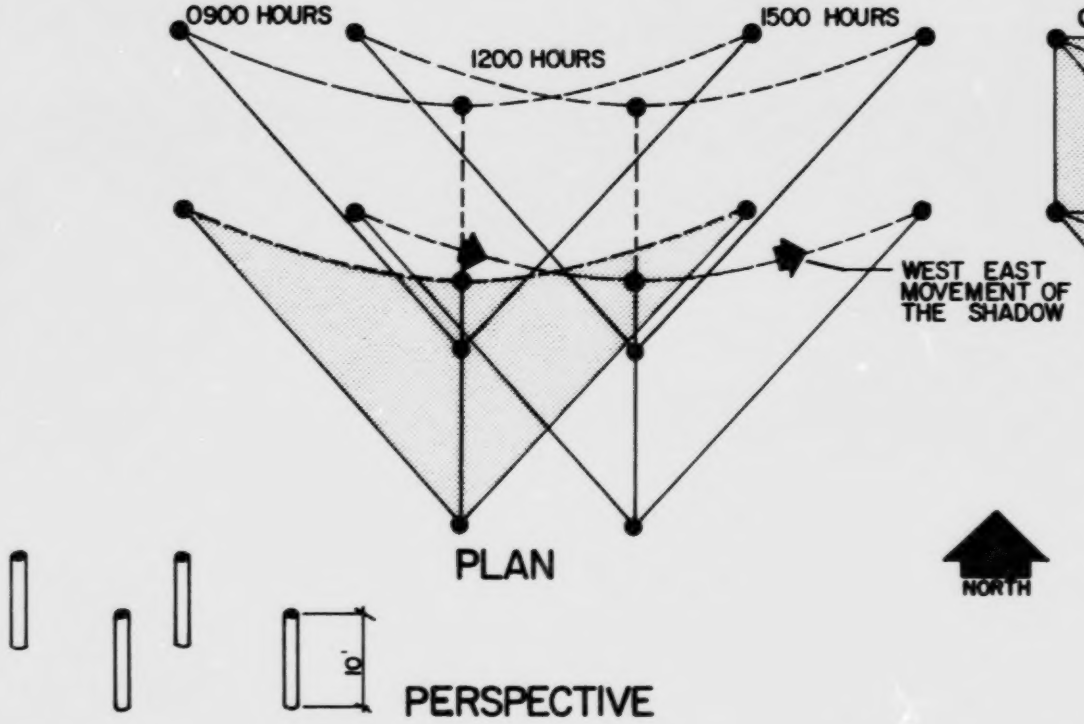


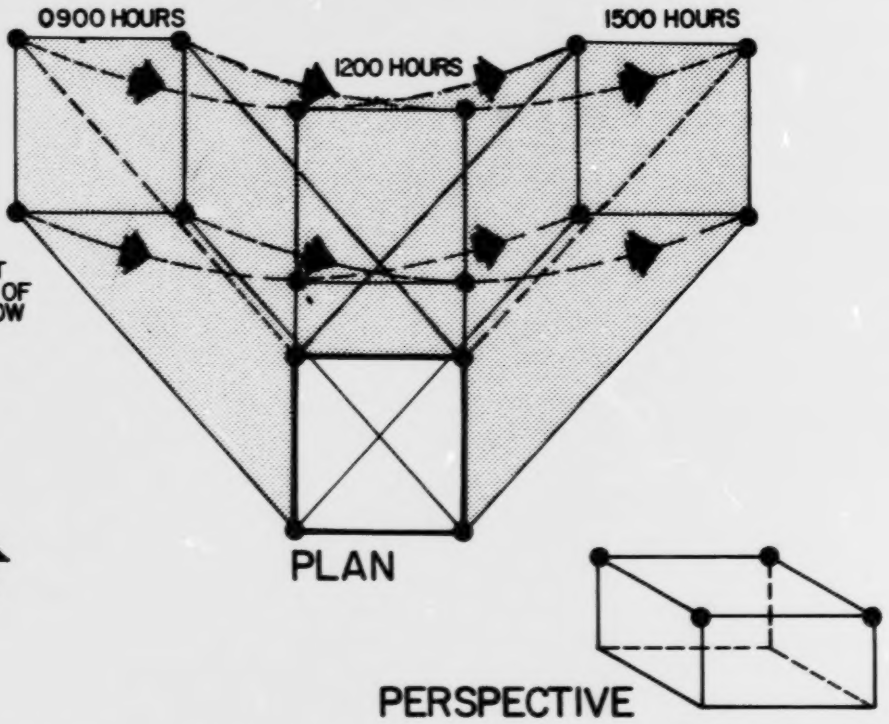
3. TO TRANSFER ALL FIVE LINES INDICATED ON THE TEMPLATE (UPPER EDGE OF ACETATE) ONTO THE PLAN THAT THE OBJECT (I.E. 10 FOOT POLE) IS DRAWN ON, MAKE A MARK BETWEEN THE EDGE OF TEMPLATE AT THE APPROPRIATE LINE AND THE PLAN OBJECT IS DRAWN ON.



4. JOIN ALL FIVE MARKS ON THE PLAN TO THE CENTRE OF THE OBJECT AND MARK CALCULATED SHADOW LENGTHS ON THE RESPECTIVE LINES I.E. 09·00 HOURS · · 48·28 FEET, 10·00 HOURS · ·30·77 FEET, 12·00 HOURS · · 22·88 FEET, 14·00 HOURS · · 30·77 FEET, AND 15·00 HOURS · · 48·28 FEET.

SHADOW PATTERN





TASK : 2 (DECEMBER 21)
DRAW SHADOWS OF FOUR POLES EACH 10 FEET HIGH
STEP 1 SIMILARLY PLACE THE SHADOW TEMPLATE ON EACH POLE AND MARK THREE POINTS 0900 , 1200 AND 1500 HOURS FOR EACH POLE
STEP 2 CONNECT CASTED SHADOWS AS SHOWN

TASK : 3 (DECEMBER 21)
DRAW A COMPOSITE SHADOW OF A CUBICLE SHOWN ON THE PLAN. THE HEIGHT IS 10 FEET.
STEP 1 THE SAME AS TASK 2
STEP 2 CONNECT CASTED SHADOWS AS SHOWN

SHADOW PATTERN

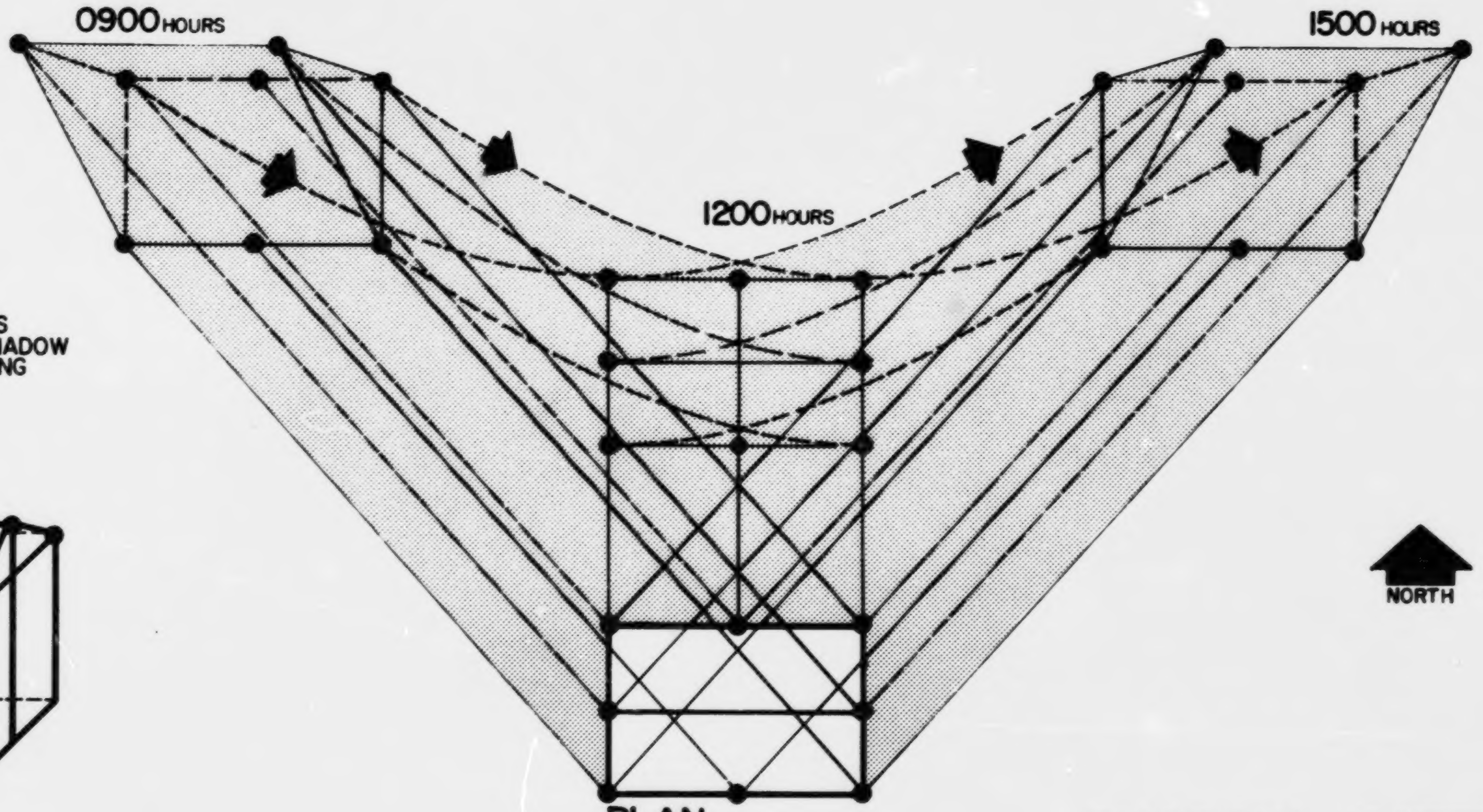
TASK : 4

DRAW A COMPOSITE SHADOW (0900 – 1500) OF THE GIVEN BUILDING (DECEMBER 21)

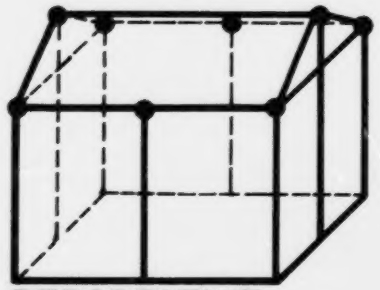
STEP : 1
ABSTRACT THE BUILDING INTO A NUMBER OF POLES

STEP : 2
DEVELOP SHADOW LENGTHS FOR EACH POLE ON THE PLAN

STEP : 3
CONNECT THE SHADOW LENGTH LINES FROM THE POLES TO ARRIVE AT THE SHADOW PATTERN OF THE BUILDING



PLAN



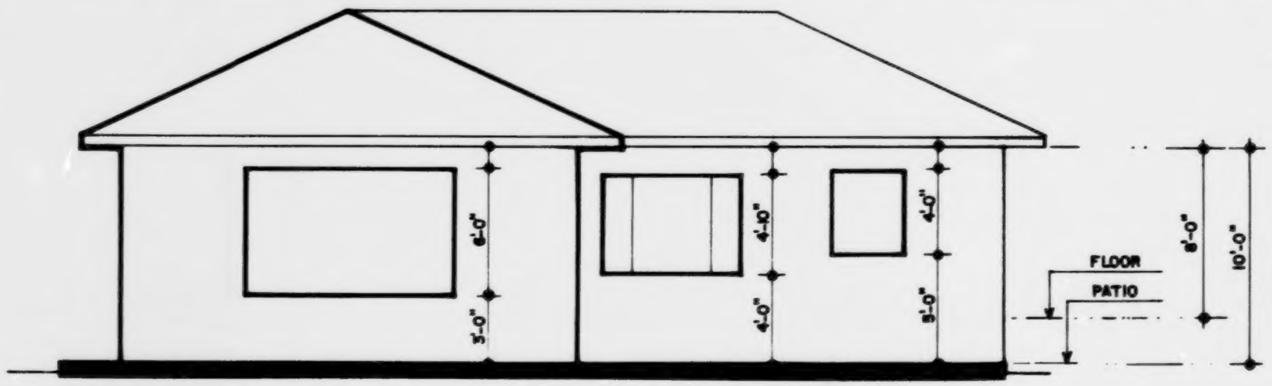
PERSPECTIVE

SHADOW PATTERN

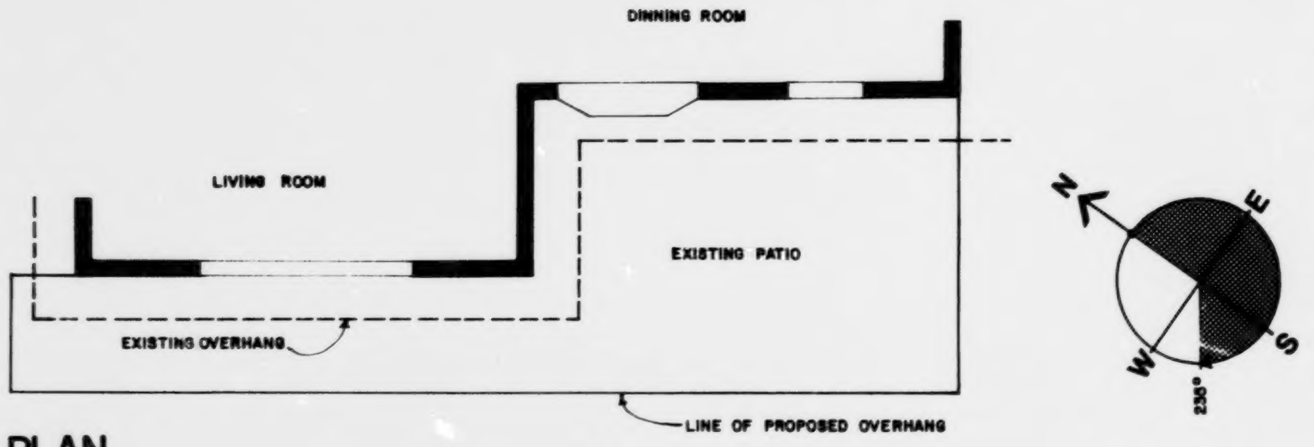
TASK : 5

DESIGN AN OVERHEAD SUNSCREEN FOR AN EXISTING OUTDOOR PATIO. SUN LIGHT MUST BE ALLOWED TO ENTER THE DWELLING DURING THE PERIOD BETWEEN SEPTEMBER AND MARCH.

THE FACE OF THE HOUSE IS 235° DUE NORTH.

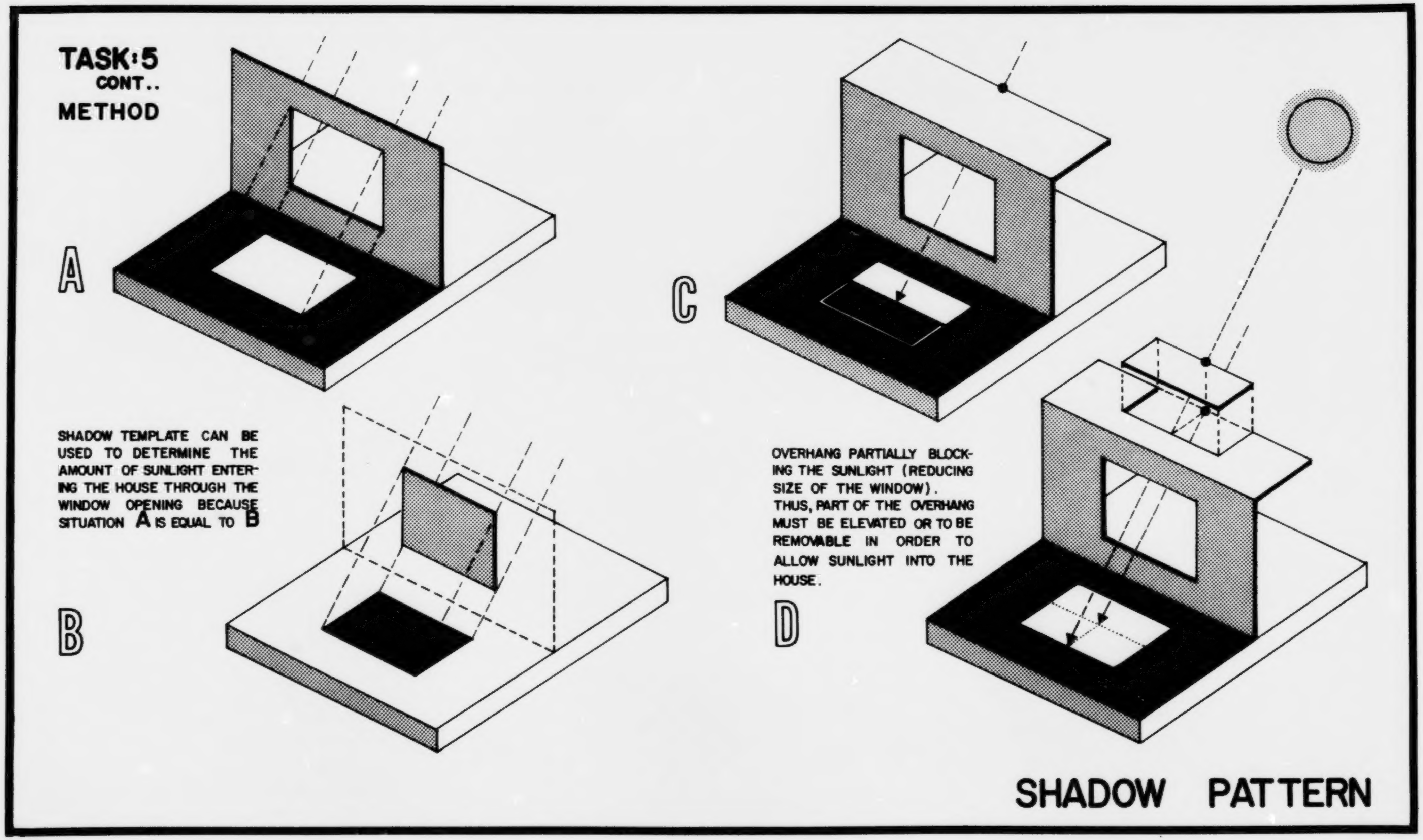


ELEVATION

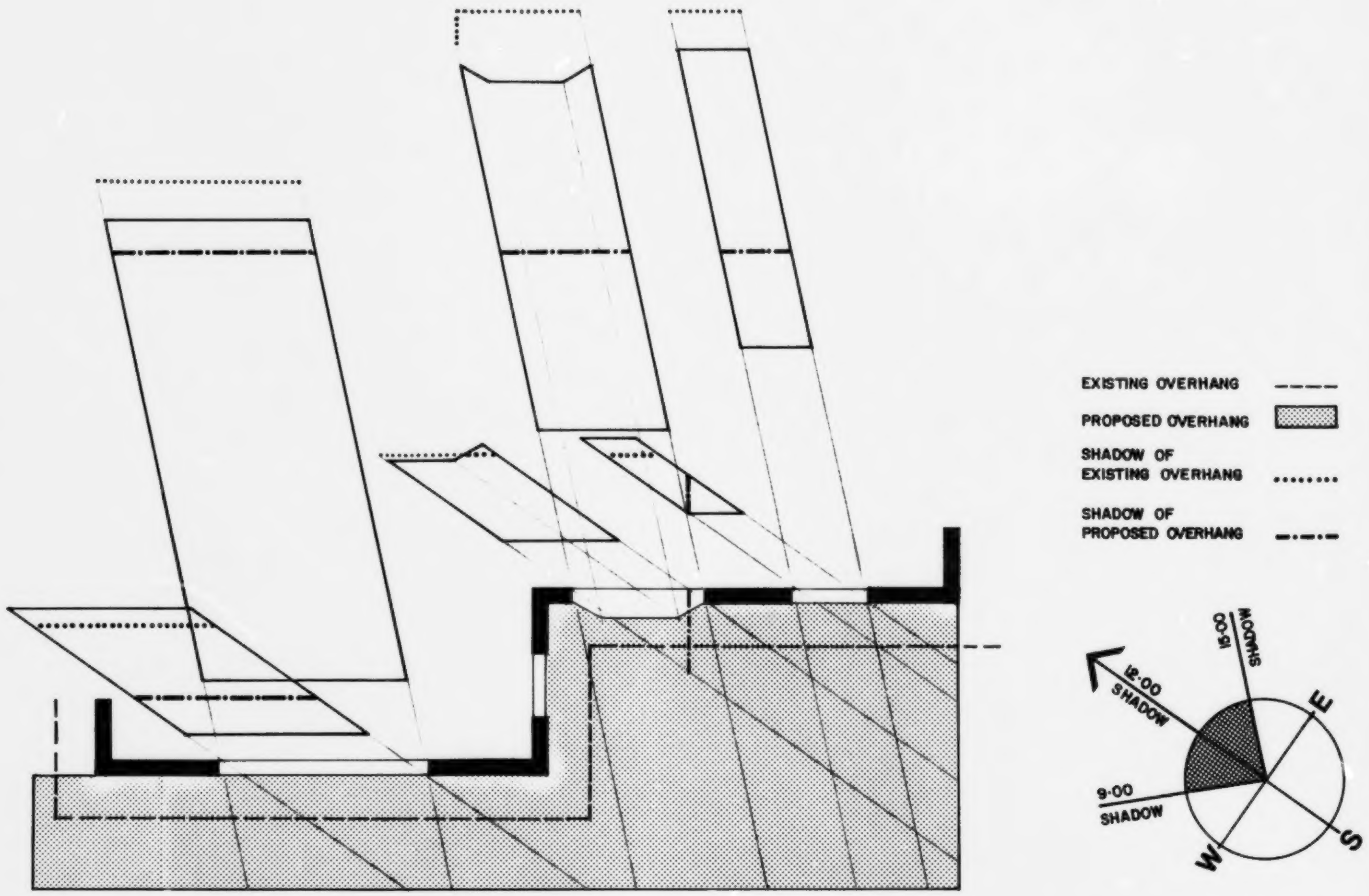


PLAN

SHADOW PATTERN


TASK:5
CONT..
METHOD
A
SHADOW TEMPLATE CAN BE USED TO DETERMINE THE AMOUNT OF SUNLIGHT ENTERING THE HOUSE THROUGH THE WINDOW OPENING BECAUSE SITUATION A IS EQUAL TO B
B
C
OVERHANG PARTIALLY BLOCKING THE SUNLIGHT (REDUCING SIZE OF THE WINDOW). THUS, PART OF THE OVERHANG MUST BE ELEVATED OR TO BE REMOVABLE IN ORDER TO ALLOW SUNLIGHT INTO THE HOUSE.
D
SHADOW PATTERN

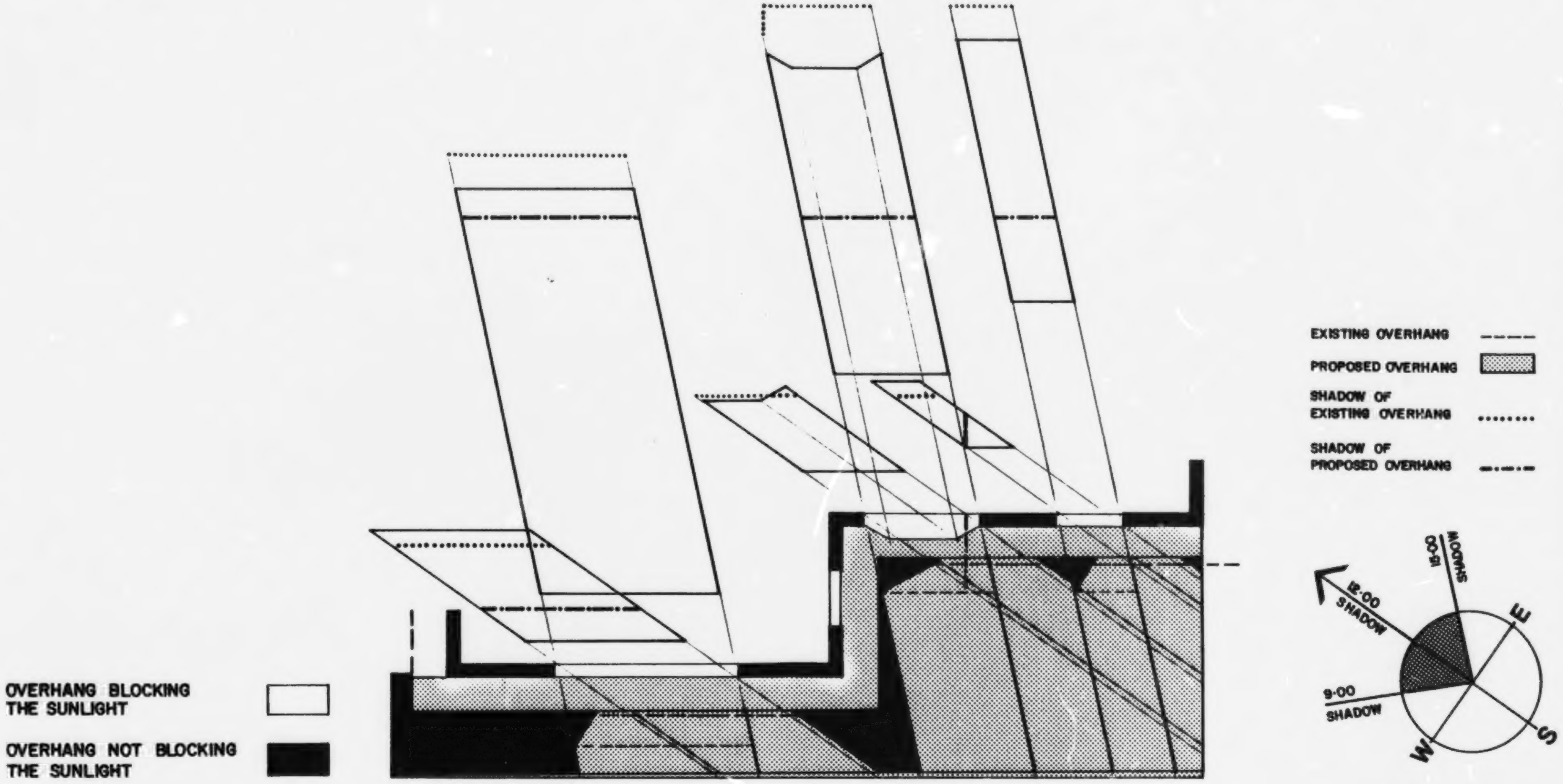
TASK : 5 CONT..



JANUARY 21

SHADOW PATTERN

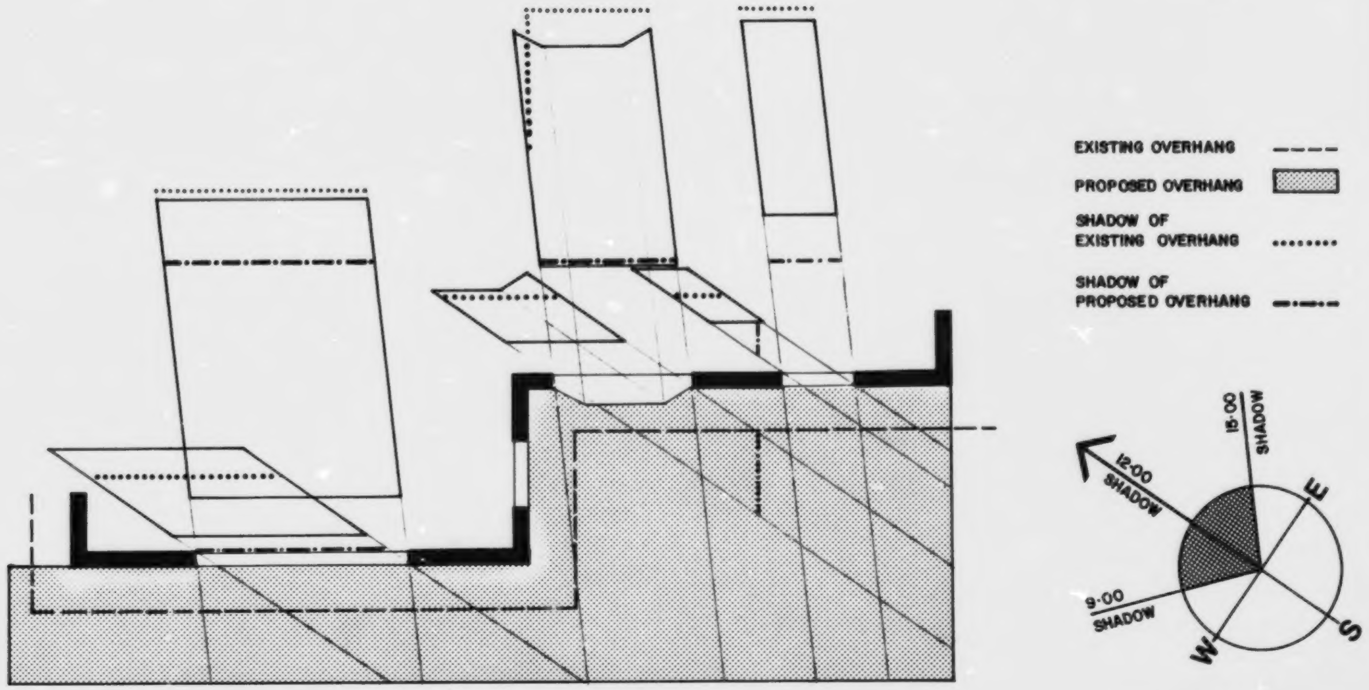
TASK : 5 CONT..



JANUARY 21

SHADOW PATTERN

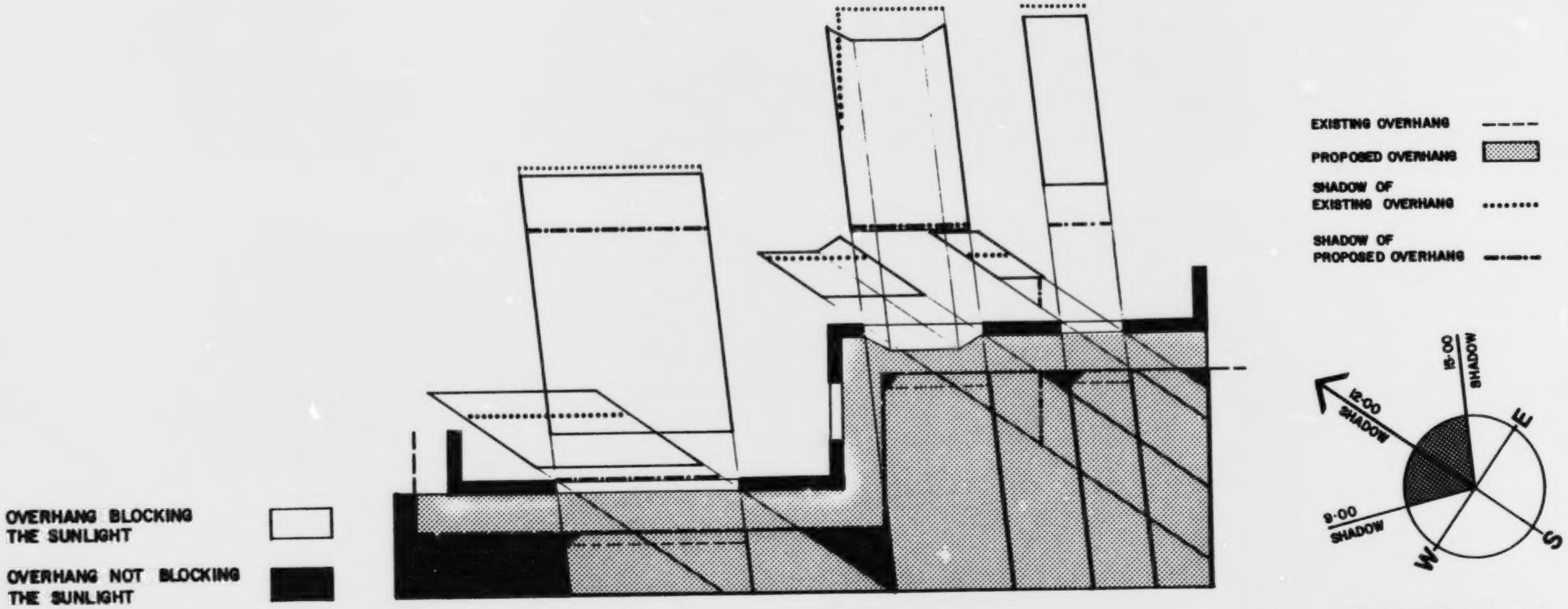
TASK : 5 CONT..



FEBRUARY 21

SHADOW PATTERN

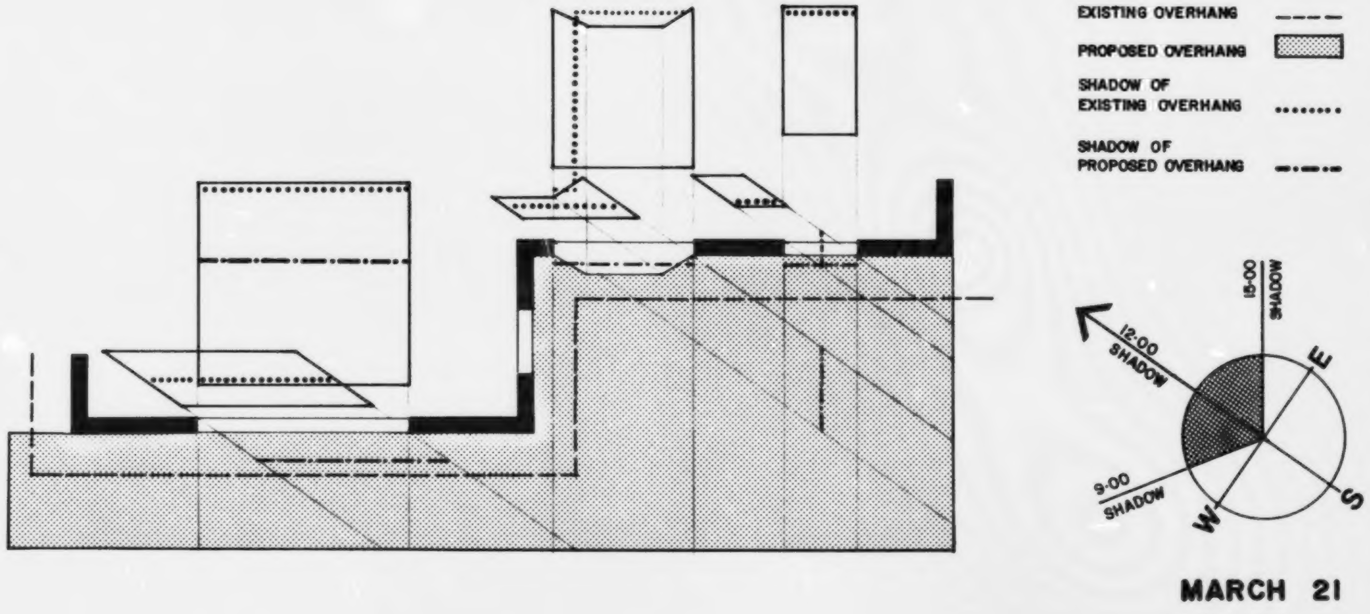
TASK : 5 CONT..



FEBRUARY 21

SHADOW PATTERN

TASK : 5 CONT..



SHADOW PATTERN

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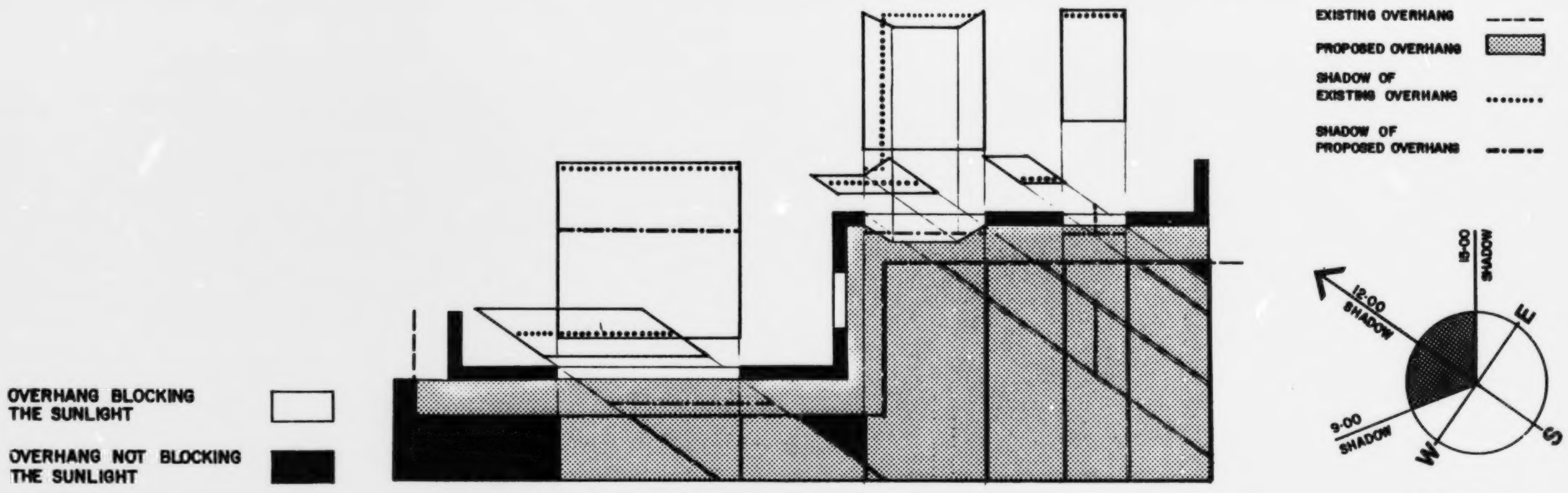
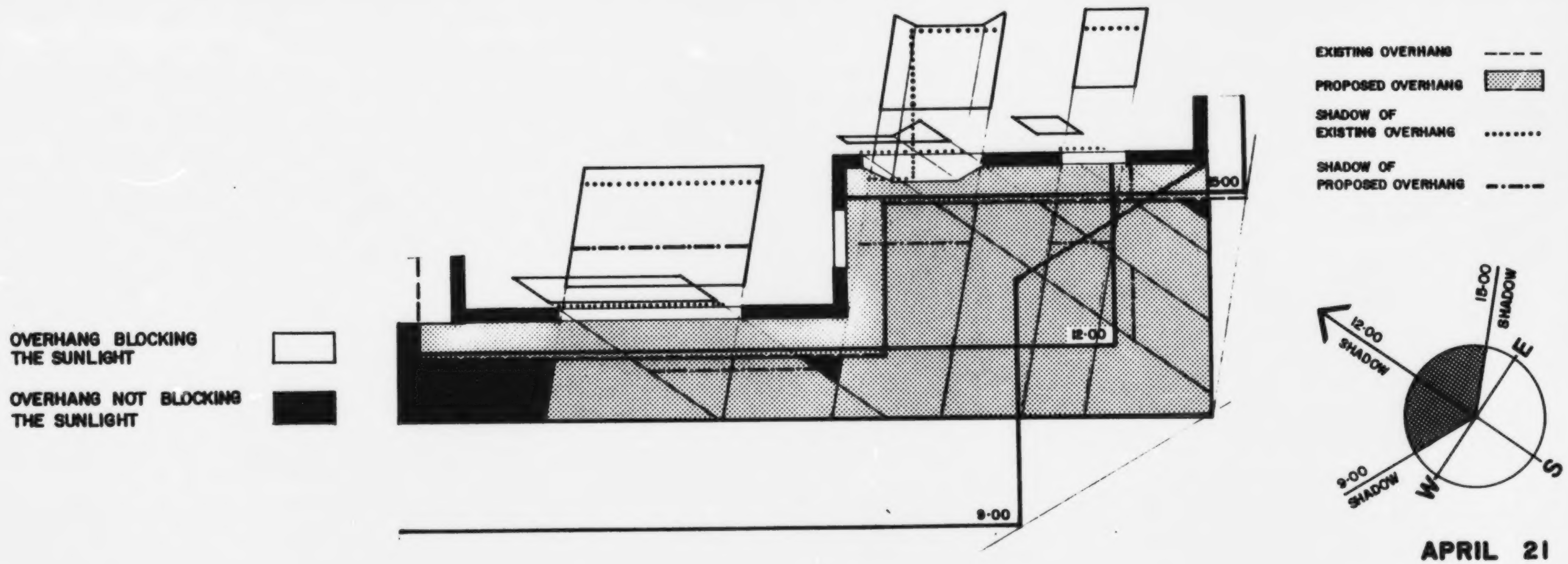


MARCH 21

SHADOW PATTERN

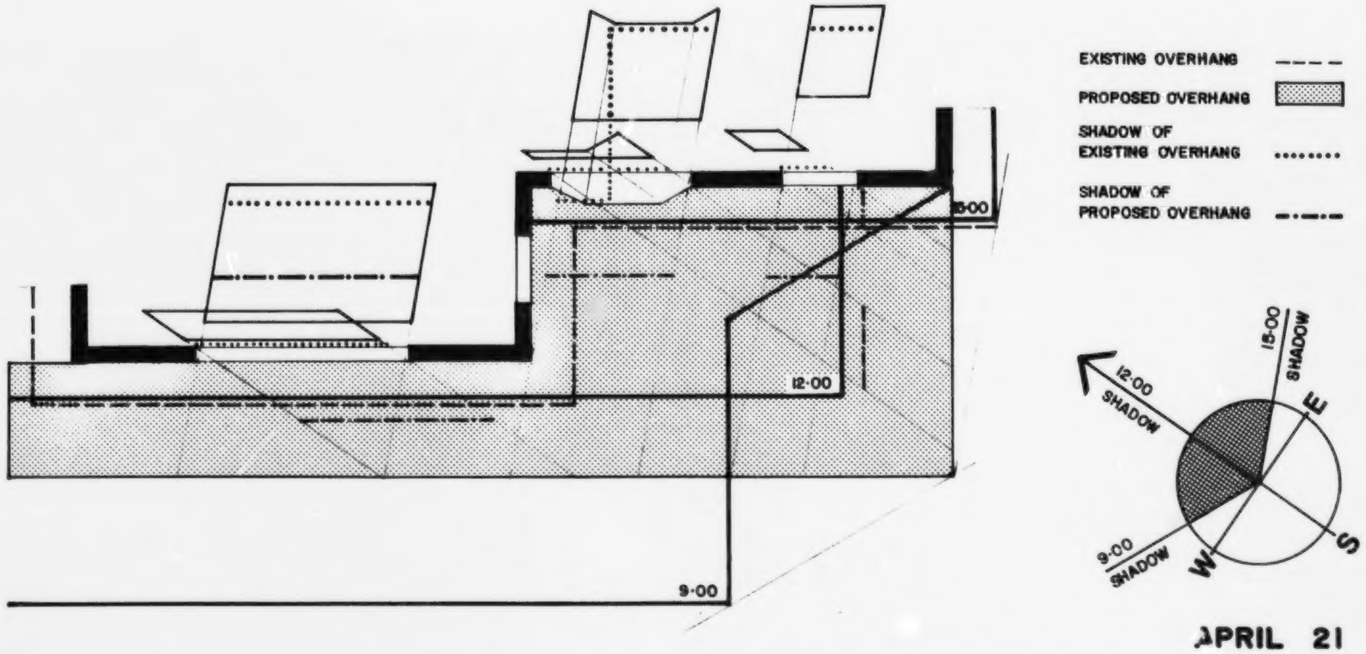
TASK : 5 CONT..



APRIL 21

SHADOW PATTERN

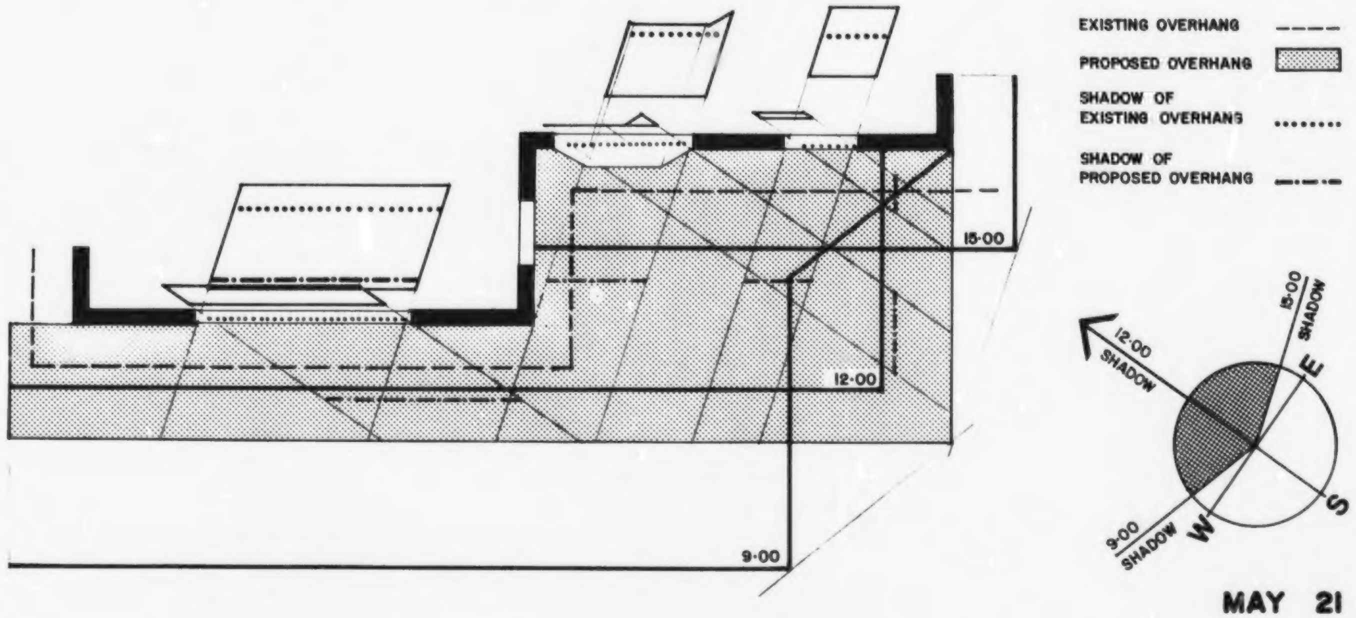
TASK : 5 CONT..



APRIL 21

SHADOW PATTERN

TASK : 5 CONT..



SHADOW PATTERN

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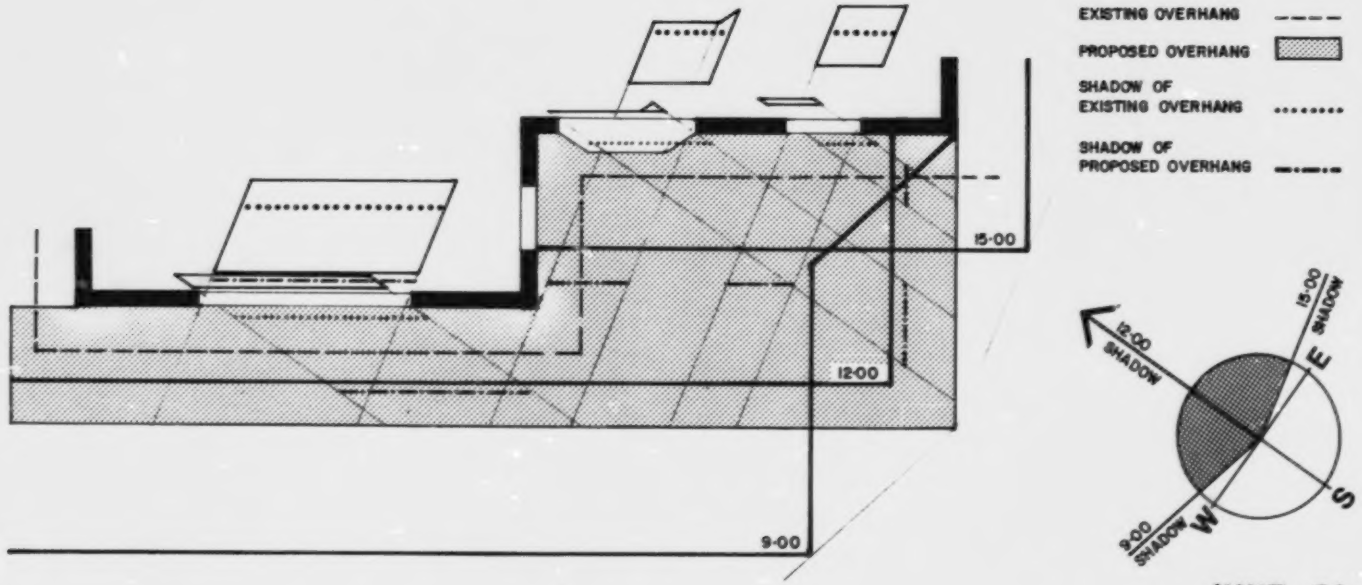

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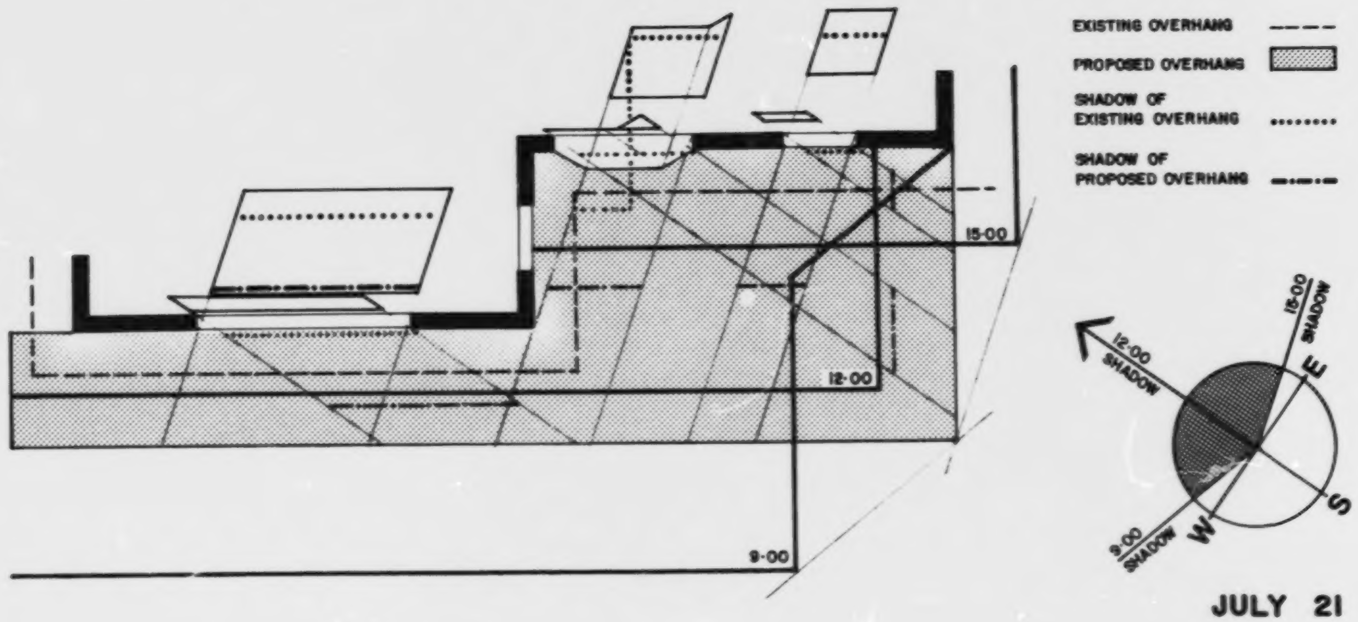

SHADOW PATTERN

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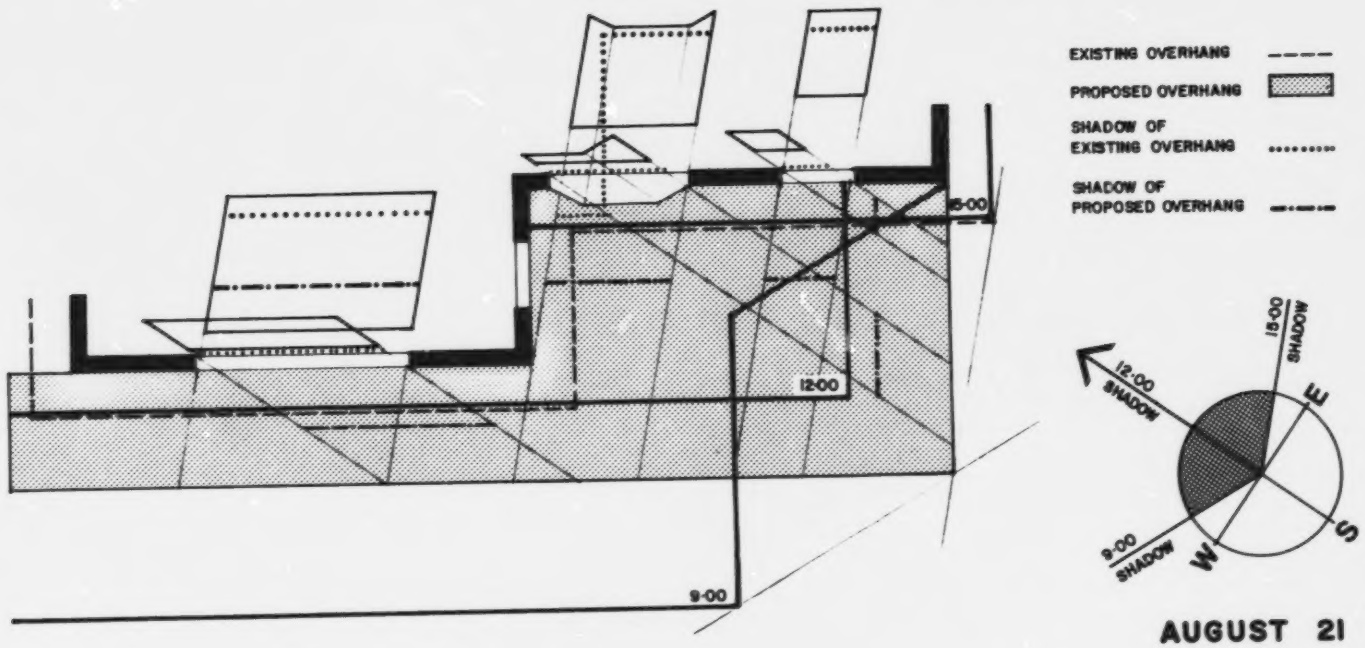
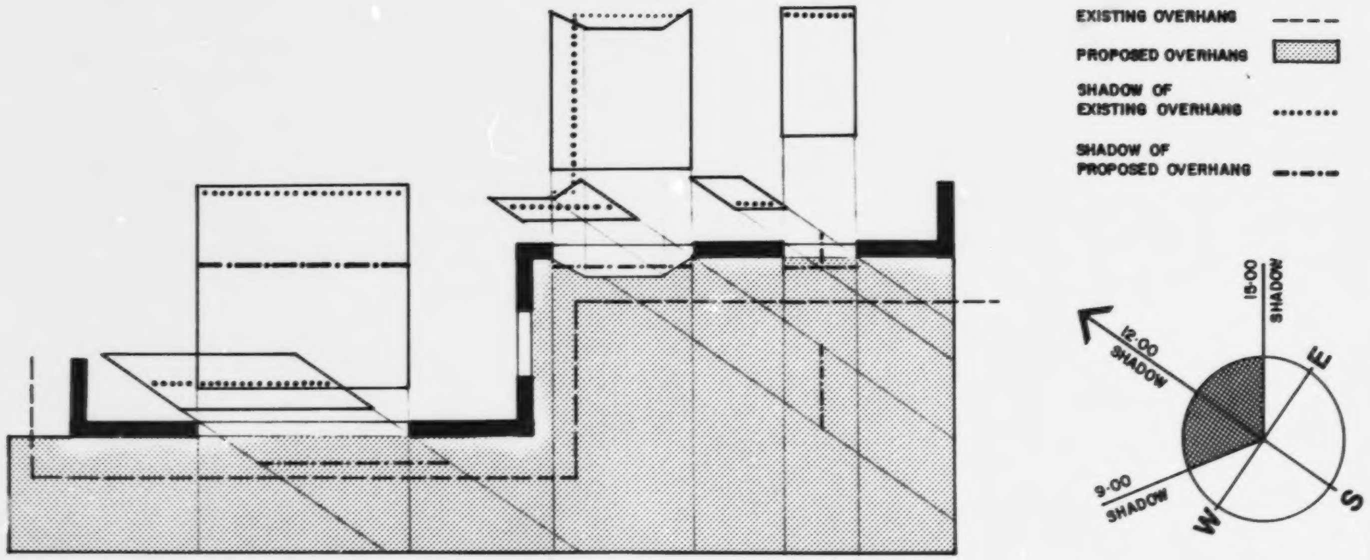


AUGUST 21

SHADOW PATTERN

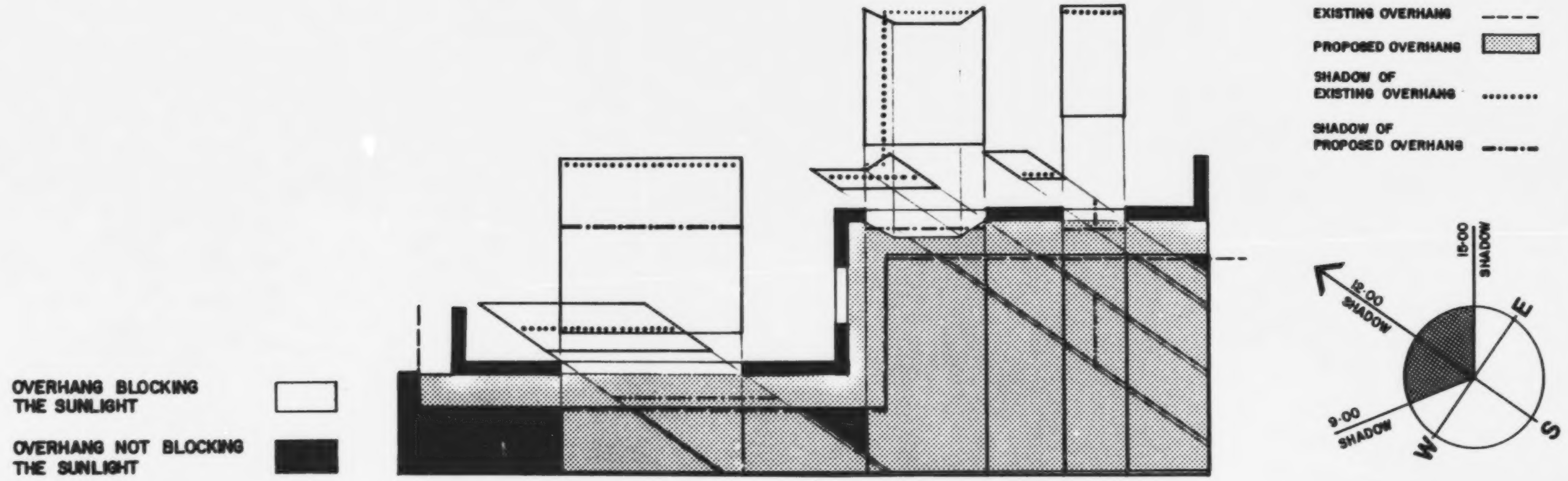
TASK : 5 CONT..



SEPTEMBER 21

SHADOW PATTERN

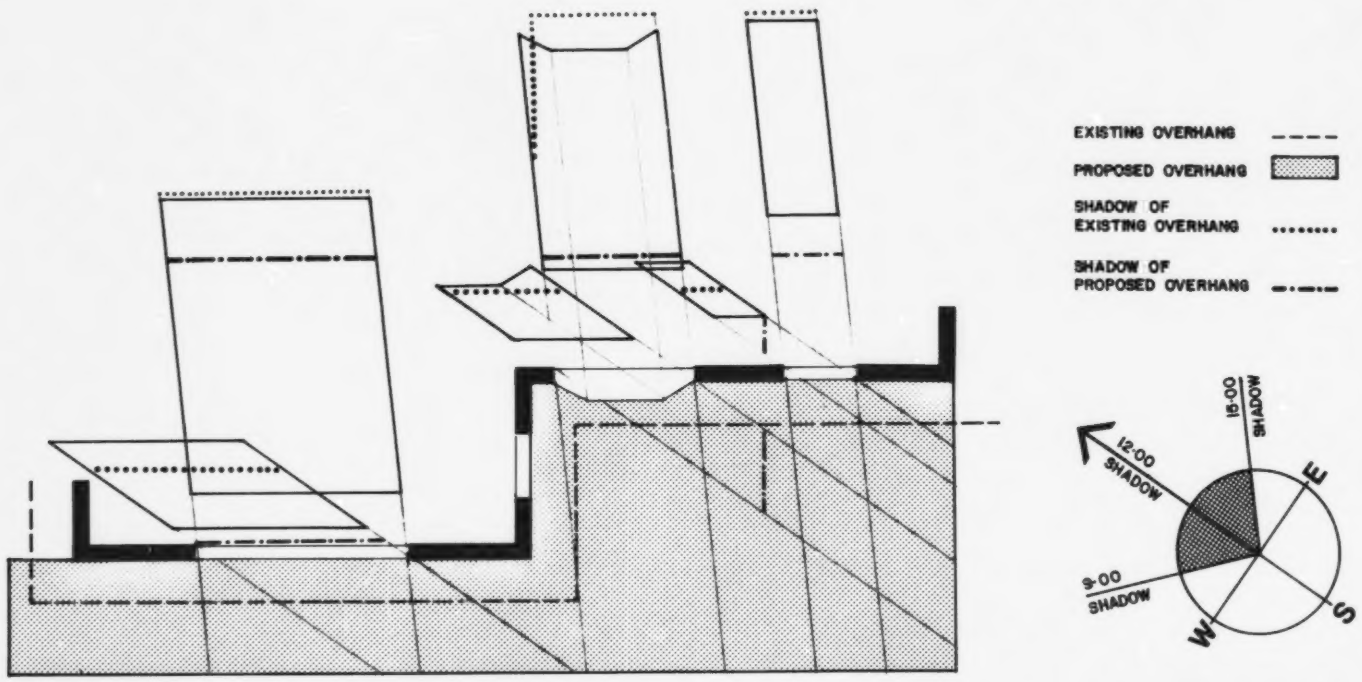
TASK : 5 CONT..



SEPTEMBER 21

SHADOW PATTERN

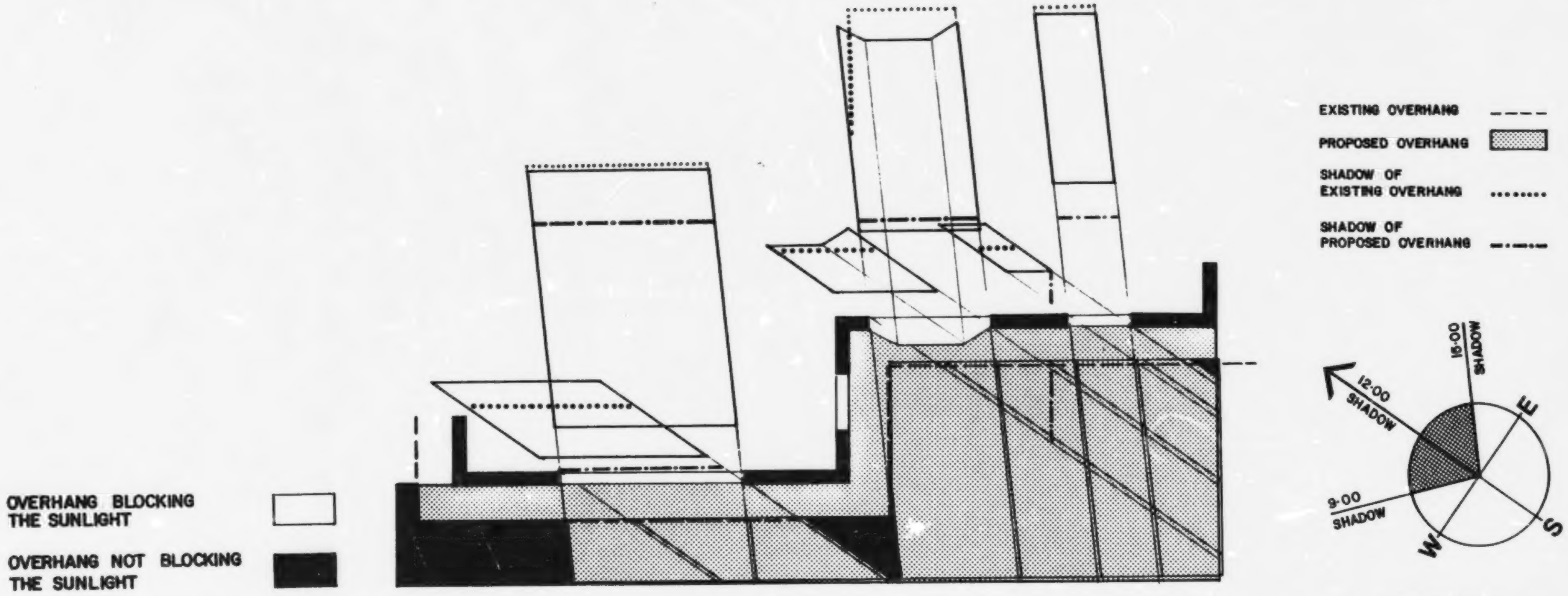
TASK : 5 CONT..



OCTOBER 21

SHADOW PATTERN

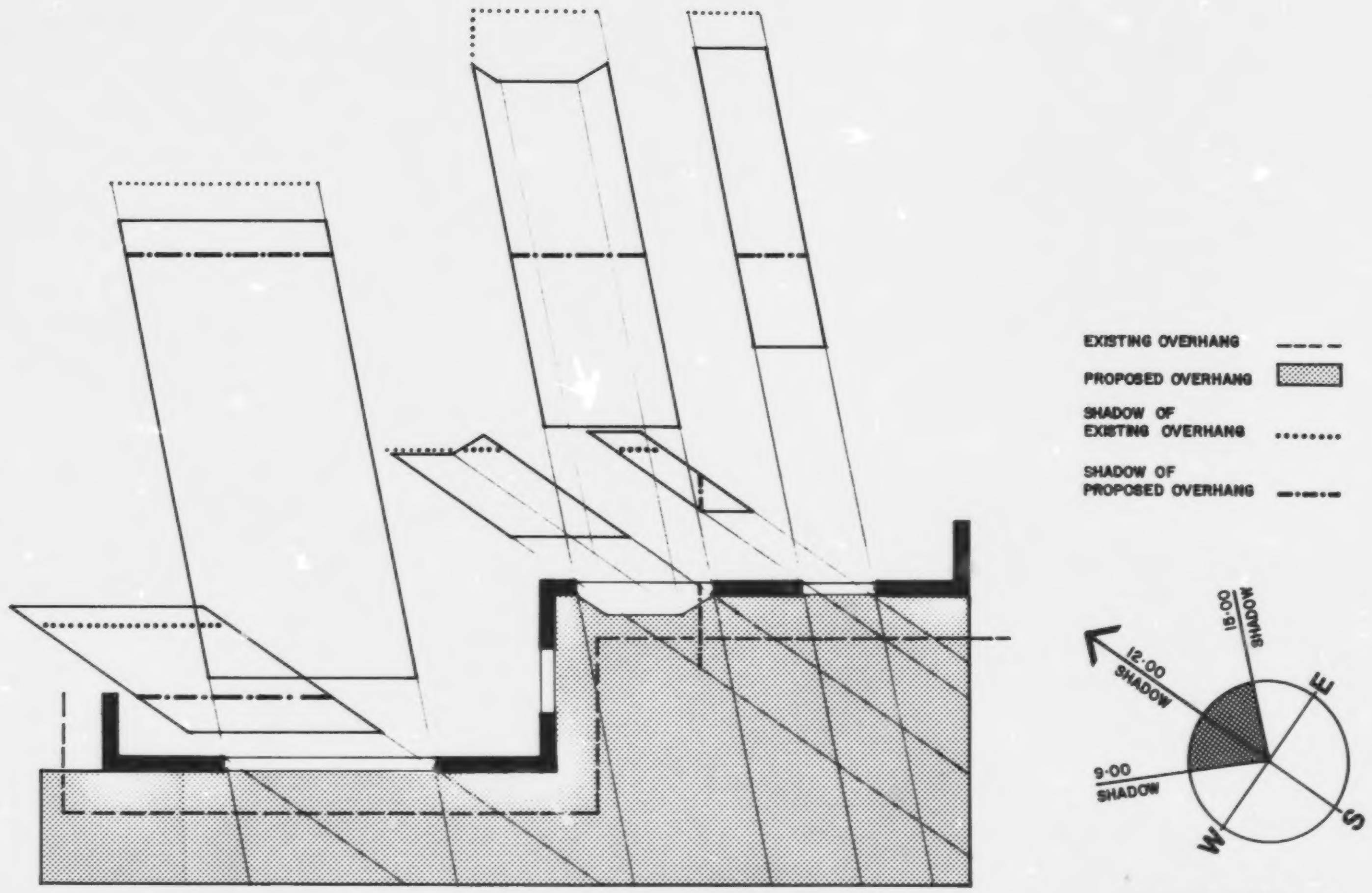
TASK : 5 CONT..



OCTOBER 21

SHADOW PATTERN

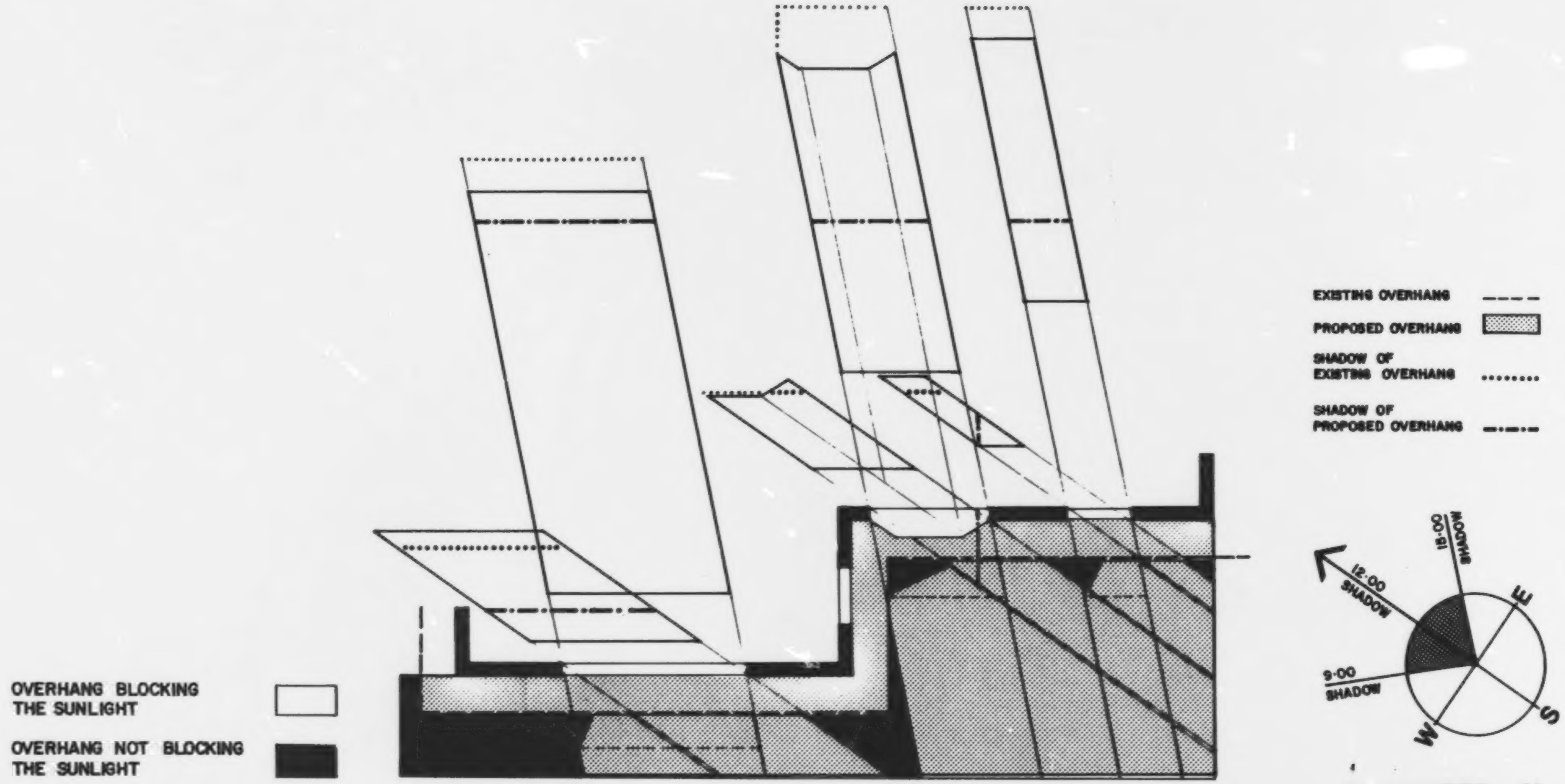
TASK : 5 CONT..



NOVEMBER 21

SHADOW PATTERN

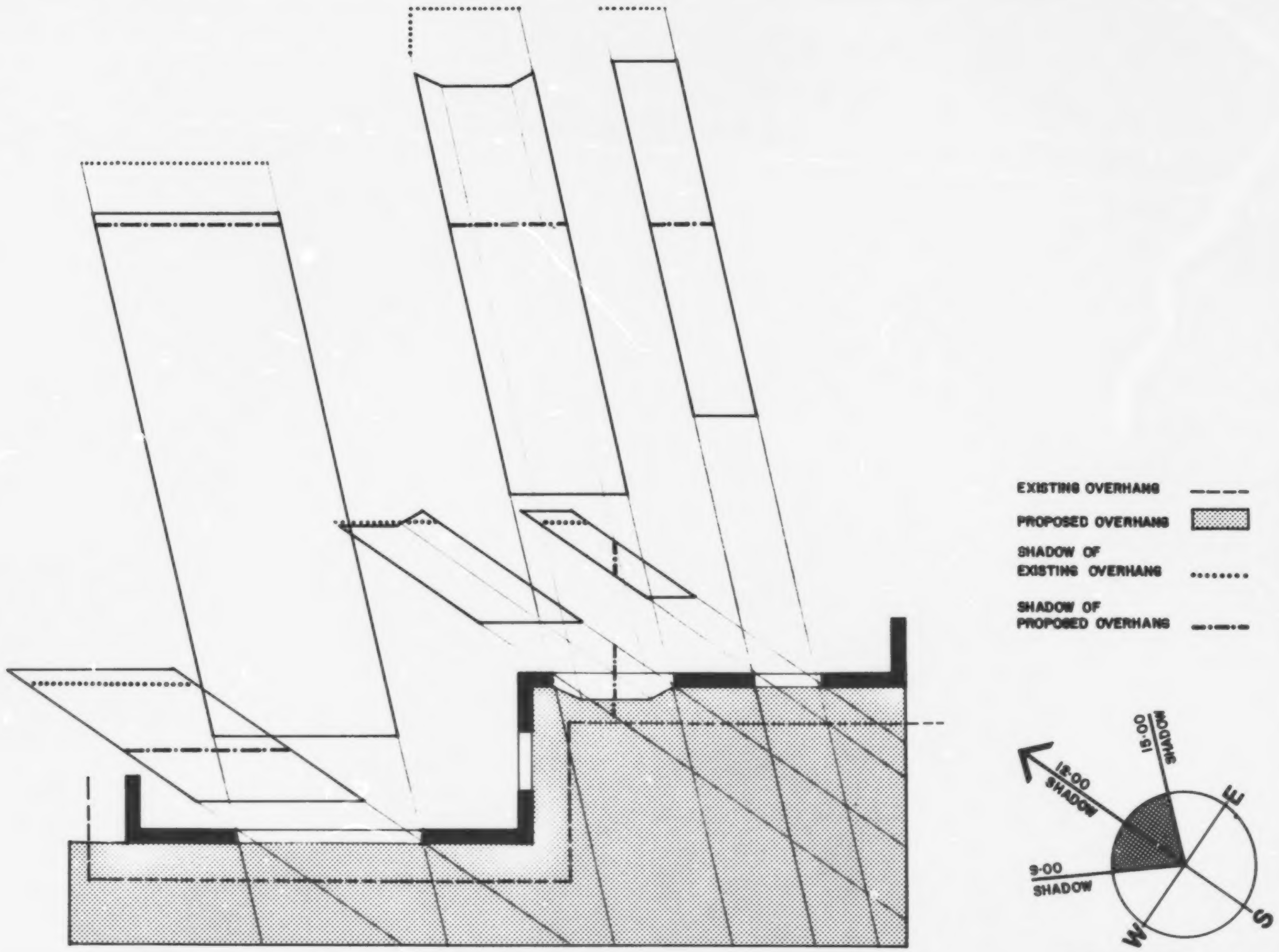
TASK : 5 CONT..



NOVEMBER 21

SHADOW PATTERN

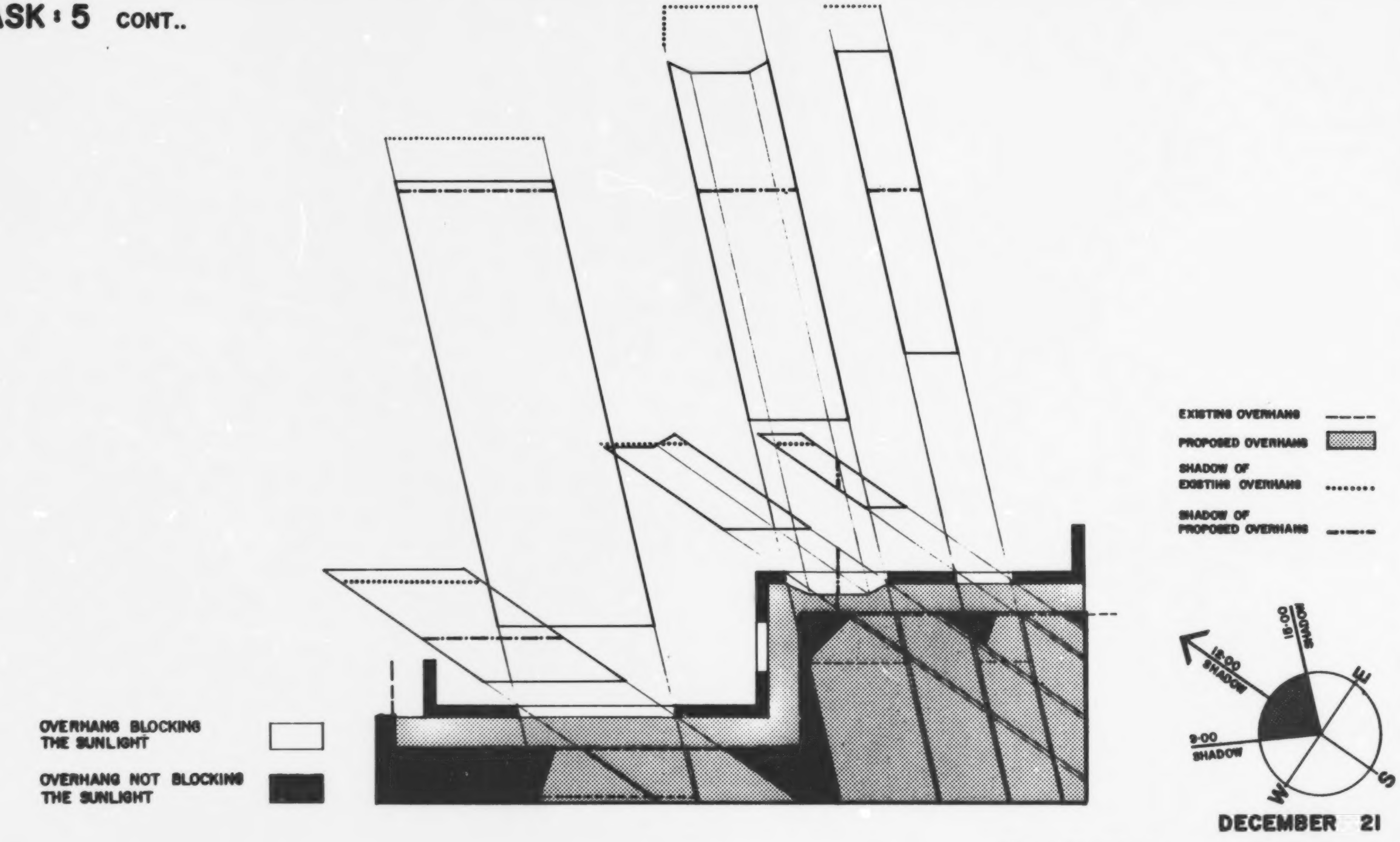
TASK : 5 CONT..



DECEMBER 21

SHADOW PATTERN

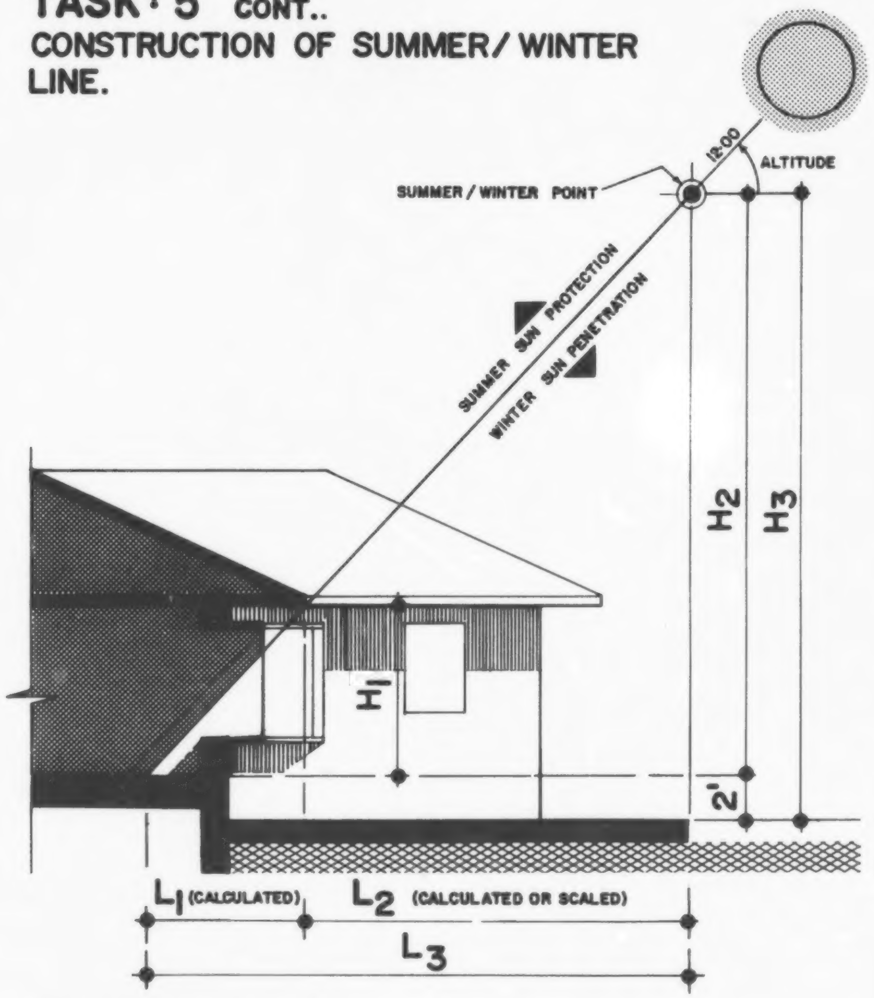
TASK : 5 CONT..



SHADOW PATTERN

TASK : 5 CONT..

CONSTRUCTION OF SUMMER/ WINTER LINE.



SECTION AT AA

METHOD : 1

$L_3 = L_1 + L_2$

$H_2 = \dfrac{L_3 \times H_1}{L_1}$

L_1	CALCULATED	= 7·5'
L_2	CALCULATED OR SCALED	= 17·8'
L_3	7·5' + 17·8'	= 25·3'
H_1	GIVEN	= 8·0'
H_2	26·98'	SAY = 27·0'
H_3	27·0' + 2·0'	= 29·0'

METHOD : 2 (FROM THE TEMPLATE)

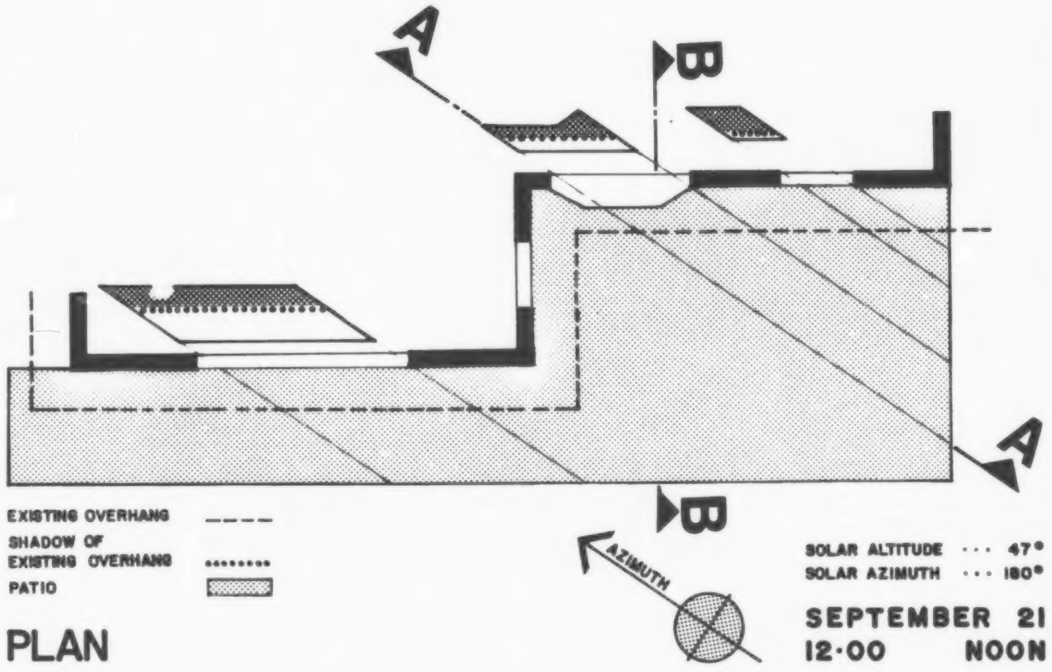
HEIGHT OF A POLE x COEFICIENT = LENGTH OF THE SHADOW

H_2 X COEFICIENT = L_3

$H_2 = \dfrac{L_3}{\text{COEFICIENT}} = \dfrac{25\cdot3}{\cdot932} = 27\cdot0'$

HEIGHT OF THE SUMMER/WINTER POINT = H_2 + 2·0' = H_3

H_3 = 27·0' + 2·0' = 29·0'

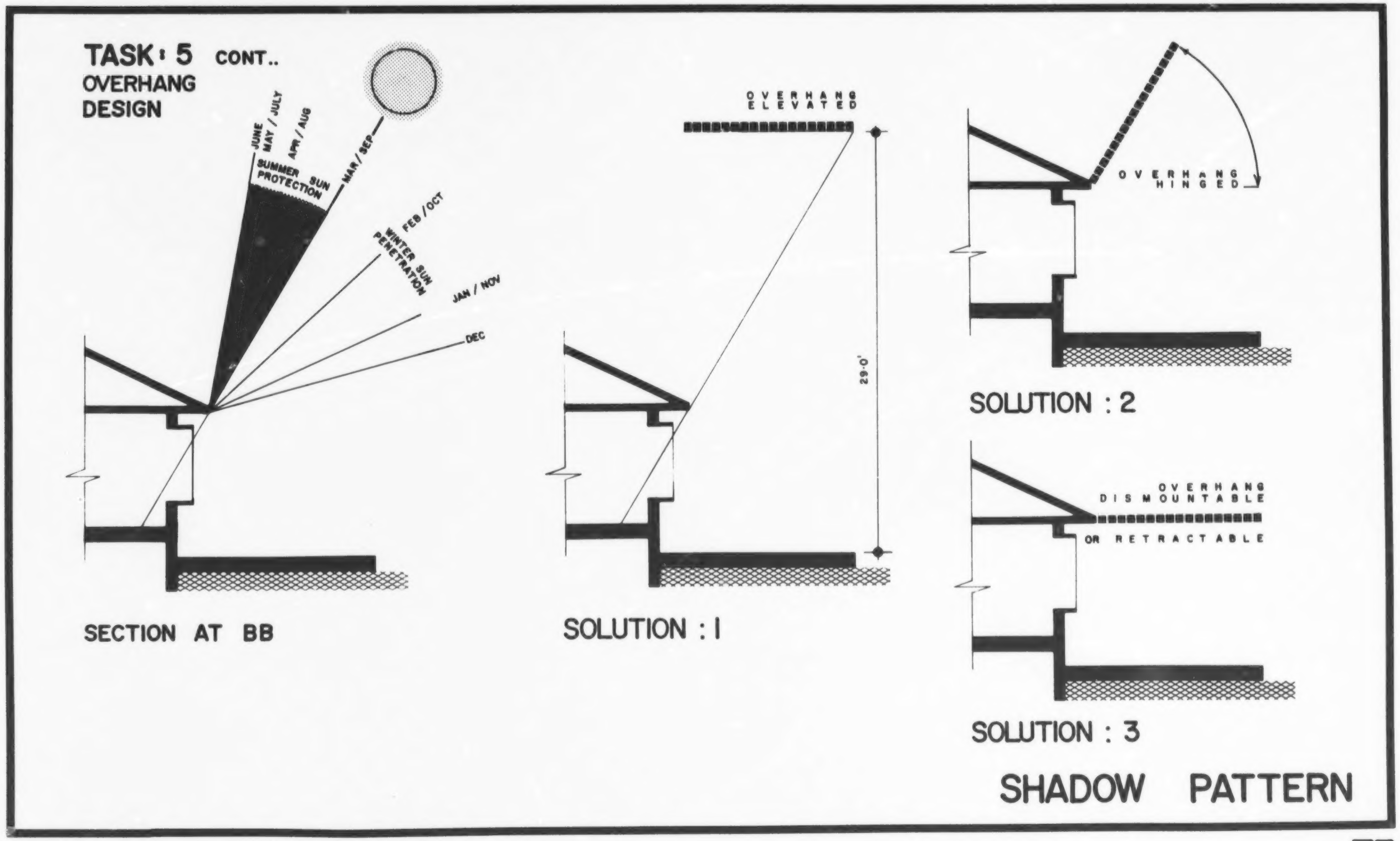


PLAN

SOLAR ALTITUDE ··· 47°
SOLAR AZIMUTH ··· 180°

SEPTEMBER 21
12·00 NOON

SHADOW PATTERN


TASK : 5 CONT..
OVERHANG DESIGN
JUNE
MAY / JULY
APR / AUG
MAR / SEP
SUMMER SUN PROTECTION
FEB / OCT
WINTER SUN PENETRATION
JAN / NOV
DEC
SECTION AT BB
OVERHANG ELEVATED
29-0'
SOLUTION : 1
OVERHANG HINGED
SOLUTION : 2
OVERHANG DISMOUNTABLE
OR RETRACTABLE
SOLUTION : 3
SHADOW PATTERN

THE ECOCHART IS AN ECOLOGICAL PORTRAIT OF A GIVEN AREA. THE ECOCHART OF HAMILTON IS COMPOSED OF:

1. A GRAPHIC REPRESENTATION AND DESCRIPTION OF THE EARTH'S SURFACE
   - TOPOGRAPHICAL RELIEF;
   - MAN-MADE FEATURES (ROADS, BUILDINGS, ETC.); AND,
   - NATURAL FEATURES (WATER, VEGETATION, ETC.).

SINCE CLIMATE HAS AN OBVIOUS AND IMPORTANT INFLUENCE ON ENERGY NEEDS, THE FOLLOWING ELEMENTS OF THE LOCAL (MICRO) CLIMATE ARE PARTICULARLY SIGNIFICANT:

2. MICRO-CLIMATIC DATA
   - AIR TEMPERATURE;
   - HOURS OF SUNSHINE;
   - DEGREE-DAYS;
   - PRECIPITATION;
   - RELATIVE HUMIDITY;
   - SOIL TEMPERATURE;
   - WIND VELOCITY AND DIRECTION;
   - SUN ANGLES AND SHADOWS; AND,
   - SUNRISE AND SUNSET.

NOTE:
- THIS DATA IS SHOWN FOR EVERY MONTH FOR TEN (10) YEARS AVERAGE, WHERE POSSIBLE.
- THE ECOCHART - GRAPHIC SUMMARY IS ENCLOSED AT THE END OF THE REPORT.
- FOR DETAILED DATA SEE APPENDICES...

ECOCHART OF HAMILTON

Air Temperature:

Our local climate is characterized by wide variations in air temperature between Seasons. These variations produce major differences in the energy requirements. Mean maximum, mean minimum, and mean of mean maximum and mean minimum of each month are expressed.

Hours of Sunshine:

The intensity and amount of solar radiation depends upon the clearness of the atmosphere, i.e., cloud cover, degree of obstruction on the horizon, latitude and time of the year. The measurement of sunshine time is absolutely essential for an active and passive solar-heating system.

Heating Degree-Days:

are the number of degrees when the daily average temperature is below 18^{0} Celsius.

A day with an average temperature of $13^{0}C$ has five (5) heating degree-days (18 - 13 = 5), while one with an average temperature of $18^{0}C$ or higher has none. The degree-days sum for a period of days represents the total heating load for that period. The relationship between degree-days and fuel consumption is linear.

Cooling Degree-Days:

are the number of degrees when the daily average temperature is above 18^{0} Celsius.

A day with an average temperature of $23^{0}C$ has five (5) cooling degree-days (23 - 18 = 5).

PRECIPITATION:

IS DEFINED AS WATER THAT FALLS ON THE EARTH'S SURFACE IN THE FORM OF RAIN, SNOW OR SLEET.

AMOUNT OF PRECIPITATION IS REQUIRED FOR THE PROPER DESIGN AND CONSTRUCTION OF A BUILDING (WATERPROOFING, INSULATION, ETC.).

LANDSCAPE DESIGN IS DIRECTLY RELATED TO PRECIPITATION.

SNOW AFFECTS ENERGY CONSUMPTION BY REFLECTING THE SUNLIGHT AND HEAT AT SOUTHERN EXPOSURES AND BY CREATING THERMAL INSULATION.

RAIN IS EXPRESSED IN MILLIMETRES (MM); SNOW IS EXPRESSED IN CENTIMETRES (CM); TOTAL PRECIPITATION IS EXPRESSED IN (MM). (RAIN PLUS THE WATER EQUIVALENT OF SNOW.)

Relative Humidity:

R/H is the percentage of water in the air at particular temperatures. Since the content of water in the air is directly related to our thermal comfort, relative humidity plays an important role in the design of passive solar heating/cooling systems.

It is expressed in percentages and usually measured in the morning and evening.

Soil Temperature:

It is necessary to survey the soil to determine its strength, bearing capacity and type. These characteristics vary, even within the same site. As soil types vary, so do their thermal characteristics. These should be studied when specifying insulation for a foundation, a slab on a grade and basement walls. Ground heat storage (accumulated during the summer) reduces the heat loss from the basement by a declining amount until frost penetrates to maximum depth. Soil temperature is taken at 10:00 a.m. at 10 cm below ground surface.

WIND SPEED AND DIRECTION:

EVERYONE IS AWARE OF HOW MUCH COLDER IT FEELS OUTDOORS ON A WINDY DAY AS COMPARED TO WHEN THERE IS NO WIND, PARTICULARLY IN THE WINTER. THE SPEED, DIRECTION AND FREQUENCY OF SEASONAL WINDS AFFECT ENERGY REQUIREMENTS. A WIND SPEED INCREASE CAUSES A MORE RAPID RATE OF HEAT TRANSFER. WIND DATA CAN BE UTILIZED FOR WIND PROTECTION DESIGN IN THE WINTER MONTHS THROUGH VEGETATION, BUILDING ENTRANCES AND SITING OF INDIVIDUAL BUILDINGS, AND FOR COOLING EFFECTS IN THE SUMMER. WIND SPEED IS MEASURED IN KILOMETRES/HOUR IN 16 DIRECTIONS. (SEE APPENDIX C)

SUN ANGLES AND SHADOWS:

THE SUN'S POSITION IN THE SKY IS DEFINED BY TWO ANGLES. THE HEIGHT ABOVE THE HORIZON IS CALLED "SOLAR ALTITUDE" AND CAN RANGE FROM 0 DEGREES (WHEN THE SUN IS ON THE HORIZON) TO 90 DEGREES (WHEN THE SUN IS AT ITS ZENITH OVERHEAD). THE POSITION OF THE SUN FROM EAST TO WEST IS CALLED "SOLAR AZIMUTH" AND IS MEASURED CLOCKWISE FROM NORTH TO THE PROJECTION OF THE SUN ON THE HORIZON. IT EQUALS 0° AT NORTH AND 90° AT EAST, 180° AT SOUTH, 270° AT WEST, AND 360° AT NORTH TO COMPLETE THE FULL CIRCLE. ANY OBJECT'S SHADOW CAN BE CAST FOR A SPECIFIC DAY AND TIME.

SUN ANGLES DETERMINE THE LENGTH AND DIRECTION OF SHADOWS. THIS MAKES IT POSSIBLE TO DESIGN OVERHANGS, SUN SCREENS, PLANT TREES STRATEGICALLY AND CONSIDER PASSIVE SOLAR DESIGN FEATURES.

FOR A FAST SHADOW-CASTING CALCULATION, THE TEMPLATES HAVE BEEN PREPARED FOR EACH MONTH AND INCLUDE NORTHERN AND SOUTHERN SLOPES UP TO 5%.

IF ONE WERE TO USE A STRICTLY RATIONAL APPROACH WHEN DESIGNING AN ENERGY-EFFICIENT URBAN FORM, THE RESULT WOULD BE A GIANT ANTHILL. SURPRISINGLY, THIS IS NOT WHAT THE LOUDEST ADVOCATES OF ENERGY EFFICIENCY ARE TRYING TO PROMOTE. ONE REASON IS THAT SUPER DENSITY HAS BEEN DISCREDITED BY ARCHITECTURAL FORM. THERE IS SOME MERIT IN A TOWERING NEEDLE BUILT IN A LARGE PARKLAND AREA. TO BUILT A DENSE FOREST OF SUCH NEEDLES IS A PERVERSION.

ANOTHER REASON FOR TURNING OUR BACKS ON SUPER-DENSITY DEVELOPMENTS IS THE WIDESPREAD BELIEF THAT WE (HUMANS) CANNOT FUNCTION IN SUCH ENVIRONMENTS. THE "SCIENTIFIC OBSERVATION" OF THE BEHAVIOUR OF LEMMINGS, RATS AND PUBLIC HOUSING TENANTS HAS TRANSFORMED THIS POINT OF VIEW INTO AN ABSOLUTE TRUTH. ONLY A FEW DARE TO RIDICULE THEMSELVES BY ATTEMPTING TO CHALLENGE THIS "INDISPUTABLE" DICTUM.

THE FACT OF THE MATTER IS THAT SHELTER IS A PART OF MAN'S OVERALL SURVIVAL STRATEGY AND LIFE-STYLE. IT DIFFERS FROM PLACE TO PLACE, FROM CULTURE TO CULTURE. AN IROQUOIS WOULD GO INSANE

IF HE WERE FORCED TO WINTER IN AN IGLOO, AND THE SAME WOULD HAPPEN TO AN INNUIT IN AN IROQUOIS LONG HOUSE. A PARISIAN, THOROUGHLY ENJOYING HIS LIFE LIVING IN AN APARTMENT IN THE MIDDLE OF THE CITY, WOULD DIE IF REPLANTED INTO NORTH AMERICAN SUBURBIA; CONVERSELY, A SUBURBAN FAMILY WOULD NEED EVEN MORE PSYCHIATRIC ASSISTANCE IF FORCED TO LIVE DOWNTOWN.

THUS, IT IS DOUBTFUL THAT HIGH OR SUPER DENSITIES ARE EVIL PER SE. THERE ARE SOCIETIES LIVING AND PROSPERING IN EXTREMELY HIGH DENSITIES. SUCH A LIFESTYLE IS A PRODUCT OF CIRCUMSTANCE: FIRST, IT HAS TO BE LEARNED AND THEN FIRMLY EMBEDDED IN THE CULTURE. THE LEARNING PROCESS, HOWEVER, IS SLOW AND REQUIRES MORE THAN ONE GENERATION TO TAKE HOLD. LIVING IN A SHOULDER-TO-SHOULDER SITUATION DEMANDS BEHAVIOURAL DISCIPLINE. BUT THIS IS, INDEED, A VERY HARD PROPOSITION TO SELL.

IN SUMMARY, THE ULTIMATE SOLUTION FOR AN ENERGY-EFFICIENT URBAN FORM IS NOT ACCEPTABLE FOR SOCIAL, CULTURAL, PSYCHOLOGICAL, BEHAVIOURAL AND OTHER REASONS. ON THE OTHER HAND, THE PRESENT

SUBURBAN DEVELOPMENTS ARE SO ENERGY INEFFICIENT THAT WE CANNOT CONTINUE TO BUILT THEM ANY LONGER. THE ERA OF ULTRA-LOW DENSITIES IS DEFINITELY OVER.

OBVIOUSLY, THE ONLY AVENUE OPEN TO US IS MEDIUM-DENSITY DEVELOPMENTS. BUT THE TASK MUST BE APPROACHED FROM A DIFFERENT ANGLE. WE SHOULD NOT ARBITRARILY STIPULATE THREE OR FOUR TYPES OF DENSITIES AND THEN ATTEMPT TO SQUEEZE OR DILUTE CONVENTIONAL STRUCTURES ACCORDINGLY, BUT RATHER, WE SHOULD SET CERTAIN LEVELS OF QUALITY -- FOR EXAMPLE, THOSE RELATED TO FAMILY LIVING - AND INCREASE DENSITIES AS MUCH AS POSSIBLE. THIS CHALLENGE HAS ALREADY BEEN UNDERTAKEN BY MANY PLANNERS AND ARCHITECTS; IN ADDITION, A NUMBER OF EXPERIMENTAL DEVELOPMENTS HAVE BEEN BUILT BY IMAGINATIVE BUILDERS. CERTAIN RESULTS ARE EVEN SURPASSING EXPECTATIONS.

IN FACT, IT HAS BEEN DEMONSTRATED THAT IT IS POSSIBLE TO IMPROVE WHAT WE CALL THE QUALITY OF A FAMILY LIVING ENVIRONMENT AND SIMULTANEOUSLY INCREASE THE DENSITY OF THE DEVELOPMENT. THE KEY TO THIS TYPE OF SUCCESS IS INNOVATIVE ARCHITECTURAL FORM.

Low-profile, "ground-oriented", medium-density developments will undoubtedly be the trend for the remainder of this century. In addition, this will be spiced by frequent attempts to revive the concept of an old-fashioned neighbourhood in terms of placing greater emphasis on mixed land use and on the close proximity of different human activities and land uses.

It is important to be aware that in this time of transition, the single-family house is bound to go through a similar process of mutation and transfiguration, as has the family car. The future customer would be looking for a comfortable, intelligently-designed product with low energy consumption and with minimal maintenance and upgrading. A block-long car is practically extinct. Does this mean that large houses built in ultra-low density subdivisions are also doomed?

Yes -- with qualifications.

THE MAINSTREAM WILL CERTAINLY BE HEADING TOWARD ADVANCED FORMS OF MEDIUM-DENSITY DEVELOPMENTS. HOWEVER, TWO GROUPS OF BUYERS WILL FIND LARGER STRUCTURES ON LARGER PIECES OF LAND CONSIDERABLY MORE APPEALING:

- THERE WILL ALWAYS BE AN INTEREST IN HIGHLY VISIBLE AND "PRESTIGE" ACCOMMODATION GENERATED BY THE AFFLUENT SEGMENT OF SOCIETY; AND,
- THE IDEA OF SELF-SUFFICIENCY (REAL OR IMAGINED) WILL MOTIVATE ANOTHER GROUP TO SEEK ACCOMMODATIONS WITH SUFFICIENT SURROUNDINGS TO GROW THEIR OWN CUCUMBERS AND TURNIPS.

POSSIBLY, A THIRD GROUP OF POTENTIAL BUYERS MIGHT BE CREATED BY A FAIRLY REMOTE, BUT NEVERTHELESS, CONCEIVABLE CIRCUMSTANCE. THE GALLOPING COMMUNICATIONS REVOLUTION COULD POTENTIALLY TRANSFORM A SINGLE-FAMILY HOME INTO AN INFORMATION TERMINAL. WITH THE NECESSITY OF GOING TO WORK, SCHOOL, OR SHOPPING REMOVED, THERE WOULD BE PRACTICALLY NO REASON TO TRAVEL, EXCEPT PERHAPS FOR THE SHEER JOY OF IT, OR FOR RECREATION. SINCE COMMUTING MIGHT BE SUBSTITUTED BY

IMPROVED COMMUNICATION, THE MAJOR ARGUMENT AGAINST LOW DENSITY WOULD BE ELIMINATED. CERTAINLY, THIS NEWLY-CREATED FORM OF LIFESTYLE MIGHT BE CONSIDERED APPEALING BY SOME.

ALTHOUGH THERE IS LITTLE HOPE FOR SUBURBANIZATION OF THE TYPE AND SCALE WE HAVE EXPERIENCED DURING THE LAST THREE DECADES, THIS DOES NOT NECESSARILY FORECAST BAD TIMES FOR THE DEVELOPMENT INDUSTRY. ON THE CONTRARY. THE ERA OF A NEW PROSPERITY FOR THOSE WHO CAN INTELLIGENTLY INTERPRET THE IMPERATIVES OF OUR TIMES IS JUST COMMENCING.

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A - • AIR TEMPERATURE
- HOURS OF SUNSHINE
- DEGREE-DAYS: HEATING AND COOLING
- PRECIPITATION
- RELATIVE HUMIDITY
- SOIL TEMPERATURE
- WIND SPEED, DIRECTION AND HOURS
- SOLAR ALTITUDE AND AZIMUTH
- SUNRISE AND SUNSET

B - • SHADOW CASTING FORMULAS

C - • WIND SPEED AND DIRECTION HOURLY

APPENDICES

- AIR TEMPERATURE
- HOURS OF SUNSHINE
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APPENDIX A

AIR TEMPERATURE: DEGREES CELSIUS (°C)

		1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	MEAN
JANUARY	Mean Maximum	- 0.8	- 4.4	- 3.8	- 0.7	- 0.3	- 1.1	0.8	- 4.3	- 8.2	- 4.5	- 2.7
	Mean Minimum	- 8.2	-12.9	-11.7	- 9.6	- 7.4	- 8.6	- 6.3	-13.8	-15.3	-11.5	-10.5
	Mean	- 4.5	- 8.7	- 7.7	- 5.1	- 3.8	- 4.8	- 2.7	- 9.1	-11.8	- 8.0	- 6.6
FEBRUARY	Mean Maximum	- 0.1	- 0.6	- 1.5	- 2.4	- 2.8	- 2.6	- 1.0	2.8	- 2.5	- 5.6	- 1.6
	Mean Minimum	- 6.4	- 8.8	- 7.9	-11.4	-11.5	-10.8	- 6.2	- 6.8	- 9.1	-15.0	- 9.4
	Mean	- 3.2	- 4.7	- 4.7	- 6.9	- 7.2	- 6.7	- 3.6	- 2.0	- 5.8	-10.3	- 5.5
MARCH	Mean Maximum	3.1	2.6	0.8	0.4	7.2	3.3	1.1	5.8	7.2	0.3	3.2
	Mean Minimum	- 4.3	- 4.5	- 6.0	- 6.9	- 0.3	- 4.4	- 5.9	- 3.2	- 2.4	- 8.2	- 4.6
	Mean	- 0.6	- 0.9	- 2.6	- 3.2	3.4	- 0.6	- 2.4	1.3	2.4	- 4.0	- 0.7
APRIL	Mean Maximum	12.2	12.4	10.7	8.7	10.7	12.7	7.9	13.5	13.3	9.7	11.2
	Mean Minimum	2.4	2.3	- 0.1	- 1.2	2.1	2.1	- 1.1	2.3	2.1	0.0	1.1
	Mean	7.3	7.4	5.3	3.8	6.4	7.4	3.4	7.9	7.7	4.9	6.2
MAY	Mean Maximum	17.7	18.3	18.6	19.6	15.7	15.8	21.8	16.5	21.8	18.4	18.4
	Mean Minimum	7.2	7.4	6.3	8.7	6.4	5.3	10.4	5.7	8.7	7.4	7.4
	Mean	12.4	12.9	12.5	14.2	11.1	10.6	16.1	11.1	15.2	12.9	12.9
JUNE	Mean Maximum	21.9	24.2	24.9	21.0	24.6	22.7	23.6	25.3	23.0	24.0	23.5
	Mean Minimum	12.6	13.7	14.3	11.5	13.9	12.6	14.3	14.1	11.4	11.3	13.0
	Mean	17.3	18.9	19.6	16.3	19.2	17.7	18.9	19.7	17.2	17.7	18.2
JULY	Mean Maximum	26.2	26.7	25.9	25.9	26.9	26.4	27.0	24.7	26.6	26.3	26.3
	Mean Minimum	16.8	17.0	14.2	15.5	15.5	14.7	15.2	14.3	15.7	13.8	15.3
	Mean	21.5	21.9	20.1	20.8	21.2	20.6	21.1	19.5	21.2	20.1	20.8
AUGUST	Mean Maximum	29.3	26.7	26.1	24.3	27.7	26.1	24.6	24.2	24.2	26.0	25.9
	Mean Minimum	17.6	16.3	13.3	14.3	16.6	14.9	14.8	13.2	13.6	14.5	14.9
	Mean	23.4	21.5	19.7	19.3	22.2	20.5	19.7	18.7	18.9	20.3	20.4
SEPTEMBER	Mean Maximum	22.3	21.9	22.5	21.4	22.4	19.4	18.0	18.5	19.9	21.0	20.7
	Mean Minimum	12.4	12.7	12.9	11.2	10.2	8.8	8.6	8.8	12.3	10.1	10.8
	Mean	17.3	17.3	17.7	16.3	16.3	14.1	13.3	13.7	16.1	15.6	15.8
OCTOBER	Mean Maximum	14.4	15.3	17.9	11.4	15.9	13.1	15.2	10.7	13.3	13.1	14.0
	Mean Minimum	6.0	8.2	8.6	2.2	6.7	2.7	5.6	2.3	4.3	3.8	5.0
	Mean	10.2	11.8	13.3	6.8	11.3	7.9	10.4	6.5	8.8	8.5	9.5
NOVEMBER	Mean Maximum	7.7	8.7	6.9	4.1	7.0	7.1	11.4	3.5	7.3	7.6	7.1
	Mean Minimum	1.3	2.6	- 0.8	- 1.3	0.6	0.3	2.8	- 4.1	1.3	- 1.3	0.1
	Mean	4.5	5.7	3.1	1.4	3.8	3.7	7.1	- 0.3	4.3	3.2	3.6
DECEMBER	Mean Maximum	- 0.7	0.6	3.8	1.3	- 0.6	1.2	0.2	- 2.9	- 0.6	1.2	0.4
	Mean Minimum	- 6.9	- 5.9	- 4.4	- 5.3	- 6.9	- 4.1	- 7.5	-11.4	- 6.8	- 5.9	- 6.5
	Mean	- 3.8	- 2.7	- 0.3	- 2.0	- 3.7	- 1.4	- 3.7	- 7.2	- 3.7	- 2.4	- 3.1
YEARLY	Mean Maximum											12.2
	Mean Minimum											3.2
	Mean											7.5

SOURCE: Environment Canada

HOURS OF SUNSHINE

		1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	MEAN
JANUARY	Possible											290.6
	Actual	96.3	83.0	92.7	101.9	129.2	86.4	86.5	103.6	92.5	79.4	95.2
FEBRUARY	Possible											292.9
	Actual	132.0	129.4	68.1	97.8	104.1	142.7	72.3	113.3	110.3	Missing	107.8
MARCH	Possible											368.1
	Actual	162.2	141.6	136.0	119.6	96.9	125.7	144.5	121.5	181.1	Missing	136.6
APRIL	Possible											413.8
	Actual	172.8	187.7	188.1	183.5	181.3	185.8	213.6	240.1	220.1	Missing	197.0
MAY	Possible											452.6
	Actual	250.0	189.4	266.1	250.1	156.5	226.0	257.2	209.3	335.5	Missing	237.6
JUNE	Possible											458.2
	Actual	179.7	258.2	275.4	173.2	239.2	250.3	289.8	263.0	303.7	272.3	250.5
JULY	Possible											464.7
	Actual	281.2	228.0	289.3	264.8	294.7	329.4	346.5	257.7	294.0	288.7	287.4
AUGUST	Possible											432.1
	Actual	288.6	289.9	300.5	215.8	269.8	272.2	223.4	283.6	269.7	261.2	267.5
SEPTEMBER	Possible											374.5
	Actual	135.4	133.6	137.9	166.7	199.5	165.4	168.4	202.6	121.2	187.1	161.8
OCTOBER	Possible											342.3
	Actual	132.8	85.8	131.4	108.1	145.6	185.1	148.9	132.1	177.6	147.1	139.4
NOVEMBER	Possible											291.5
	Actual	76.2	63.8	79.8	53.8	71.0	79.1	97.2	120.8	34.1	111.2	78.7
DECEMBER	Possible											280.3
	Actual	90.6	76.2	49.9	63.1	39.6	63.0	67.7	67.4	103.7	65.2	68.6
YEARLY	Possible											4,461.6
	Actual											2,028.1

SOURCE: Royal Botanical Garden

HEATING DEGREE-DAYS $(> 18^{o}C)$

MONTH	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	MAX.	MIN.	MEAN 10 YEARS
JANUARY	696.2	824.2	796.2	717.6	676.4	705.5	641.8	839.1	922.7	806.7	922.7	641.8	762.6
FEBRUARY	592.3	633.5	634.1	721.4	702.2	689.0	602.7	579.6	667.6	792.5	792.5	579.6	661.5
MARCH	576.4	588.5	636.3	657.1	452.2	574.7	632.4	518.5	482.7	680.8	680.8	452.2	580.0
APRIL	323.1	322.5	383.5	428.0	348.4	320.9	439.6	308.1	311.6	394.7	439.6	308.1	358.0
MAY	191.2	169.8	181.3	128.0	218.1	236.3	94.5	215.9	119.1	180.8	236.3	94.5	173.5
JUNE	64.3	44.0	31.9	80.2	18.7	40.1	30.2	20.6	54.2	53.1	80.2	18.7	43.7
JULY	11.5	3.8	8.2	22.0	4.9	2.7	7.4	7.8	7.3	15.3	22.0	2.7	9.1
AUGUST	0.5	7.7	18.1	25.3	9.3	1.6	17.3	33.6	31.6	2.3	33.6	0.5	14.7
SEPTEMBER	74.7	65.9	61.5	76.4	103.3	130.8	141.3	121.1	75.2	90.8	141.3	61.5	94.1
OCTOBER	251.6	196.7	153.8	353.3	212.1	316.5	234.4	354.9	284.0	295.6	354.9	153.8	265.3
NOVEMBER	406.0	372.5	448.4	499.0	428.6	430.8	327.3	548.8	411.0	446.2	548.8	327.3	431.9
DECEMBER	674.2	639.0	566.5	618.1	570.9	600.5	671.7	780.7	672.1	631.9	780.7	566.5	652.6
YEARLY	3862.0	3868.1	3919.8	4326.4	3845.1	4049.4	3840.6	4328.7	4039.1	4390.7	4390.7	3840.6	4047.0

SOURCE: Environment Canada

COOLING DEGREE-DAYS (< 18°C)

	1976	1977	1978	1979	MAX.	MIN.	MEAN 4 YEARS
JANUARY	-	-	-	-	-	-	-
FEBRUARY	-	-	-	-	-	-	-
MARCH	-	-	-	-	-	-	-
APRIL	6.8	2.3	-	-	6.8	2.3	4.6
MAY	-	34.3	23.5	11.4	34.3	11.4	23.0
JUNE	71.3	31.8	44.3	37.8	71.3	31.8	46.3
JULY	54.7	105.0	78.9	97.9	105.0	54.7	84.1
AUGUST	55.9	58.3	75.4	51.0	75.0	51.0	60.2
SEPTEMBER	18.1	19.7	18.1	19.7	19.7	18.1	18.9
OCTOBER	-	-	-	5.4	5.4	5.4	5.4
NOVEMBER	-	-	-	-	-	-	-
DECEMBER	-	-	-	-	-	-	-
YEARLY	206.8	251.4	240.2	223.2	317.5	174.7	242.5

PRECIPITATION: Rain is expressed in millimetres (mm).
Snow is expressed in centimetres (cm).
Total Precipitation is expressed in millimetres (mm).
(Rain plus water equivalent of snow.)

		1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	MEAN
JANUARY	Rainfall	59.2	8.9	6.4	18.8	24.4	39.4	46.0	17.9	Tr	28.4	25.0
	Snowfall	40.6	23.1	30.7	45.5	11.4	33.5	17.8	90.8	52.6	98.3	44.4
	Precipitation	99.8	30.2	35.1	57.7	37.6	71.6	64.8	92.8	48.1	122.1	66.0
FEBRUARY	Rainfall	0.0	7.4	45.0	3.3	22.4	34.0	36.6	39.1	23.4	Tr	21.1
	Snowfall	4.3	22.6	43.4	61.2	43.9	40.9	38.9	17.5	9.7	28.7	31.1
	Precipitation	4.3	29.5	87.4	61.2	64.3	68.6	76.2	54.7	32.8	26.3	50.5
MARCH	Rainfall	32.8	35.6	9.1	73.9	114.6	34.3	44.7	116.1	63.6	50.9	57.6
	Snowfall	8.9	14.2	46.2	24.4	18.3	22.9	35.8	32.3	31.6	8.9	24.4
	Precipitation	41.7	52.8	55.6	97.5	132.6	60.5	86.9	151.7	94.3	59.9	83.4
APRIL	Rainfall	108.2	76.0	23.1	54.4	65.8	74.2	23.6	92.0	73.9	51.6	64.3
	Snowfall	5.1	2.3	2.5	17.8	1.3	5.3	18.0	3.5	5.9	5.6	6.7
	Precipitation	113.3	78.2	25.7	71.9	67.6	82.3	45.7	95.5	79.8	58.4	71.8
MAY	Rainfall	84.1	59.9	35.1	107.7	78.0	110.0	54.9	90.2	37.1	64.5	72.2
	Snowfall	-	-	-	-	-	Tr	-	Tr	Tr	-	0.0
	Precipitation	84.1	59.9	35.1	107.7	78.0	110.0	54.9	90.2	37.1	64.5	72.2
JUNE	Rainfall	57.2E	59.7	32.8	97.5	63.0	98.6	74.9	74.3	83.9	43.5	68.5
	Snowfall	-	-	-	-	-	-	-	-	-	-	0.0
	Precipitation	57.2E	59.7	32.8	98.5	63.0	93.6	74.9	74.3	83.9	43.5	68.5
JULY	Rainfall	77.0	103.6	54.4	54.6	73.4	52.1	87.1	83.5	76.4	42.1	70.4
	Snowfall	-	-	-	-	-	-	-	-	-	-	0.0
	Precipitation	77.0	103.6	54.4	54.6	73.4	52.1	87.1	83.5	76.4	42.1	70.4
AUGUST	Rainfall	4.6	45.7	97.5	150.4	8.4	6.9	150.9	61.7	87.3	67.0	68.0
	Snowfall	-	-	-	-	-	-	-	-	-	-	0.0
	Precipitation	4.6	45.7	97.5	150.4	8.4	6.9	150.9	61.7	87.3	67.0	68.0
SEPTEMBER	Rainfall	23.4	106.2	23.6	44.5	28.7	73.4	89.3	83.3	206.1	136.1	81.5
	Snowfall	-	-	-	-	-	-	-	-	-	-	0.0
	Precipitation	23.4	106.2	23.6	44.5	28.7	73.4	89.3	83.3	206.1	136.1	81.5
OCTOBER	Rainfall	70.6	64.0	53.9	80.3	164.6	25.4	50.0	57.6	39.0	78.5	68.4
	Snowfall	Tr	Tr	-	0.8	-	Tr	-	Tr	Tr	-	0.8
	Precipitation	70.6	64.0	53.9	80.3	164.6	25.4	50.0	57.6	39.0	78.5	69.6
NOVEMBER	Rainfall	61.0	49.3	18.0	42.9	104.7	73.2	53.2	15.3	63.3	51.6	53.3
	Snowfall	7.6	13.7	27.4	20.6	3.1	2.8	10.1	5.2	8.4	12.0	11.1
	Precipitation	68.6	62.0	49.8	67.1	108.5	76.5	66.4	20.0	69.2	62.6	65.1
DECEMBER	Rainfall	18.8	28.2	70.6	67.1	37.6	12.5	34.3	10.0	63.7	51.8	39.5
	Snowfall	68.6	76.0	33.0	41.7	48.5	50.8	60.3	40.7	66.4	19.0	50.5
	Precipitation	87.4	96.3	105.7	108.2	87.6	59.2	92.8	42.9	136.6	77.5	89.4
YEARLY	Rainfall											689.8
	Snowfall											169.0
	Precipitation											856.4

Tr = Trace - Negligible amount of rain or snow. E = Estimated.
SOURCE: Environment Canada.

RELATIVE HUMIDITY PERCENTAGE

		1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	MEAN
JANUARY	8:00 a.m.	77	77	70	73	77	83	79	76	77	83	77
	7:00 p.m.	75	74	70	72	72	75	73	78	75	80	74
FEBRUARY	8:00 a.m.	73	74	74	73	77	73	80	78	75	84	76
	7:00 p.m.	70	70	73	71	74	72	77	75	76	75	73
MARCH	8:00 a.m.	68	75	73	72	87	79	76	77	81	82	77
	7:00 p.m.	65	68	70	72	77	71	74	74	74	74	72
APRIL	8:00 a.m.	70	73	66	70	73	72	67	73	71	69	70
	7:00 p.m.	62	61	58	62	64	68	62	64	65	60	63
MAY	8:00 a.m.	75	78	70	75	76	74	74	78	66	78	74
	7:00 p.m.	59	67	55	59	69	69	68	70	58	72	65
JUNE	8:00 a.m.	78	77	75	74	78	78	80	76	76	72	76
	7:00 p.m.	66	60	52	70	70	55	74	72	59	60	64
JULY	8:00 a.m.	77	85	75	75	78	76	73	82	78	79	78
	7:00 p.m.	62	72	65	65	65	51	67	74	65	64	65
AUGUST	8:00 a.m.	78	84	80	89	80	81	80	81	81	82	82
	7:00 p.m.	56	61	70	76	68	68	71	73	67	69	68
SEPTEMBER	8:00 a.m.	85	88	87	78	79	83	89	84	88	84	84
	7:00 p.m.	63	71	84	74	65	67	79	72	76	67	72
OCTOBER	8:00 a.m.	81	89	92	83	87	85	88	84	84	84	86
	7:00 p.m.	71	81	83	78	82	70	77	79	74	69	76
NOVEMBER	8:00 a.m.	84	82	81	82	82	87	86	79	85	84	83
	7:00 p.m.	78	79	76	79	81	81	83	71	81	80	79
DECEMBER	8:00 a.m.	81	80	79	82	76	85	81	75	82	83	80
	7:00 p.m.	79	78	76	92	77	82	78	76	81	79	80
YEARLY MEAN	8:00 a.m.	77	80	76	77	79	80	79	79	79	80	79
	7:00 p.m.	67	70	69	73	72	69	74	73	71	71	71

SOURCE: Environment Canada.

SOIL TEMPERATURE ^{o}C AM - 10 CM BELOW GROUND SURFACE

	1969	1970	1971	1972	1973	1974	1975	1976	1977	1978	MEAN
JANUARY				1.3	0.5	1.2	1.4	1.2	- 0.3	0.7	0.9
FEBRUARY				0.1	0.6	0.7	0.6	1.7	- 1.1	0.3	0.4
MARCH				- 0.2	3.3	1.9	1.2	3.0	1.0	0.2	1.5
APRIL				3.3	7.5	6.7	4.8	8.3	7.3	4.0	6.0
MAY				12.4	11.9	11.7	13.6	11.8	13.4	10.8	12.2
JUNE				17.1	19.0	17.1	19.1	18.6	17.6	17.1	17.9
JULY				21.1	22.1	19.9	21.4	20.3	21.3	20.3	20.9
AUGUST				20.8	21.9	20.5	21.0	20.3	20.8	20.7	20.9
SEPTEMBER				18.8	18.6	16.7	16.3	16.8	18.8	17.7	17.7
OCTOBER				11.2	13.8	10.8	12.7	10.7	12.2	12.3	12.0
NOVEMBER				6.2	7.2	7.6	8.9	4.3	8.8	7.8	7.3
DECEMBER				2.4	3.1	2.9	3.1	0.7	3.4	2.5	2.6
YEARLY MEAN				9.5	10.8	9.8	10.3	9.8	10.3	9.5	10.0

SOURCE: Royal Botanical Gardens

WIND SPEED (km/h), FREQUENCY & PREVAILING DIRECTION (AVERAGE 1976 – 1979).

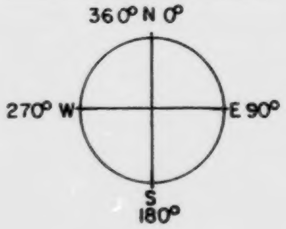
	NORTH		NNE		NE		ENE		EAST		ESE		SE		SSE	
	SPEED	HOURS	SPEED	HOURS	SPEED	HOURS	SPEED	HOURS	SPEED	HOURS	SPEED	HOURS	SPEED	HOURS	SPEED	HOURS
JANUARY	16	18	21	33	22	31	25	48	21	25	17	6	11	3	11	6
FEBRUARY	14	33	16	33	24	24	21	41	15	16	10	6	11	7	11	7
MARCH	17	11	16	16	21	71	22	78	14	30	11	9	13	10	16	17
APRIL	16	38	18	35	23	84	23	65	13	22	12	7	9	4	11	10
MAY	15	27	19	49	19	120	19	49	13	19	10	7	12	8	15	21
JUNE	12	29	14	36	16	64	14	29	10	20	10	10	10	10	14	23
JULY	12	31	14	30	15	54	15	31	9	10	8	5	9	3	11	11
AUGUST	11	27	12	33	13	65	13	55	11	22	8	7	8	3	9	7
SEPTEMBER	10	35	13	35	15	68	16	83	10	26	10	8	9	7	12	15
OCTOBER	15	35	15	43	18	70	15	43	13	20	11	9	13	8	14	17
NOVEMBER	15	12	14	26	17	46	16	52	13	30	12	3	14	5	14	8
DECEMBER	18	19	14	19	18	23	18	50	14	34	11	4	11	8	15	10
YEARLY AVG. SPEED - TOTAL HRS.	14 - 315		16 - 378		18 - 720		18·624		13·274		12 · 81		11 - 76		13 - 152	
	NORTH		NNE		NE		ENE		EAST		ESE		SE		SSE	

	SOUTH		SSW		SW		WSW		WEST		WNW		NW		NNW	
	SPEED	HOURS	SPEED	HOURS	SPEED	HOURS	SPEED	HOURS	SPEED	HOURS	SPEED	HOURS	SPEED	HOURS	SPEED	HOURS
JANUARY	17	9	25	50	22	89	27	161	25	130	22	48	21	32	15	23
FEBRUARY	12	22	19	44	21	80	24	118	25	131	21	46	19	36	17	17
MARCH	16	34	22	50	25	74	24	106	24	120	23	62	21	28	14	12
APRIL	16	28	17	38	22	66	23	57	23	102	24	63	21	50	19	33
MAY	14	68	15	55	19	62	18	51	17	71	19	49	19	36	17	24
JUNE	16	58	18	78	19	76	17	52	17	89	18	65	17	38	14	16
JULY	14	62	15	94	16	101	15	81	15	86	17	52	17	44	16	26
AUGUST	12	37	16	70	16	102	17	81	15	92	15	50	14	49	11	27
SEPTEMBER	11	36	16	58	16	80	17	73	17	76	17	40	16	32	15	28
OCTOBER	18	50	20	60	19	87	22	86	18	83	18	50	16	35	18	28
NOVEMBER	17	48	20	73	19	74	22	154	22	95	19	32	17	22	13	14
DECEMBER	17	19	21	56	25	98	26	184	23	110	22	45	20	32	17	14
YEARLY AVG. SPEED - TOTAL HRS.	15 - 471		19·726		20·989		21 - 1204		20·1185		20 - 602		18 - 434		16 - 262	
	SOUTH		SSW		SW		WSW		WEST		WNW		NW		NNW	

SOLAR ALTITUDE AND AZIMUTH FOR 43° NORTH ALTITUDE - HAMILTON

	0900 HOURS		1000 HOURS		1200 HOURS		1400 HOURS		1500 HOURS	
MONTHS	Solar ALT.°	Solar AZIM.°	Solar ALT.°	Solar AZIM.°	Solar ALT.°	Solar AZIM.°	Solar ALT.°	Solar AZIM.°	Solar ALT.°	Solar AZIM.°
JANUARY 21	14.6	136.6	21.2	149.7	27.0	180.0	21.2	210.3	14.6	223.4
FEBRUARY 21	22.3	131.3	29.6	145.6	36.2	180.0	29.6	214.4	22.3	228.7
MARCH 21	31.1	124.3	39.3	139.8	47.0	180.0	39.3	220.2	31.1	235.7
APRIL 21	40.1	115.2	49.3	131.4	58.6	180.0	49.3	228.6	40.1	244.8
MAY 21	46.0	107.0	55.9	123.0	67.0	180.0	55.9	237.0	46.0	253.0
JUNE 21	48.2	103.1	58.5	118.7	70.4	180.0	58.5	241.3	48.2	256.9
JULY 21	46.4	106.3	56.4	122.3	67.6	180.0	56.4	237.7	46.4	253.7
AUGUST 21	40.6	114.5	49.8	130.8	59.3	180.0	49.8	229.2	40.6	245.5
SEPTEMBER 21	31.1	124.3	39.3	139.8	47.0	180.0	39.3	220.2	31.1	235.7
OCTOBER 21	22.6	131.1	29.9	145.5	36.5	180.0	29.9	214.5	22.6	228.9
NOVEMBER 21	14.8	136.5	21.4	149.6	27.2	180.0	21.4	210.4	14.8	223.5
DECEMBER 21	11.7	138.5	18.0	151.2	23.6	180.0	18.0	208.8	11.7	221.5

SOURCE: National Research Council of Canada



SUNRISE AND SUNSET

MONTH	SUNRISE	SUNSET
JANUARY 21	7:46	17:18
FEBRUARY 21	7:11	17:58
MARCH 21	6:24	18:32
APRIL 21	5:31	19:09
MAY 21	4:52	19:41
JUNE 21	4:41	20:02
JULY 21	4:58	19:54
AUGUST 21	5:31	19:14
SEPTEMBER 21	6:05	18:21
OCTOBER 21	6:40	17:30
NOVEMBER 21	7:19	16:52
DECEMBER 21	7:48	16:48

- All times in Eastern Standard Time.
- For Daylight Saving Time: From last Sunday of April to last Sunday of October, add one hour.

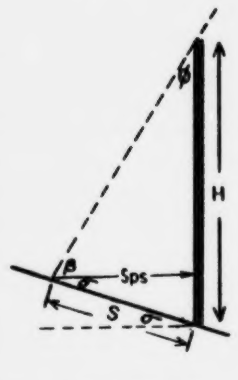
SHADOW CASTING FORMULAS

APPENDIX B

Date JANUARY 21

hours 09:00 & 15:00

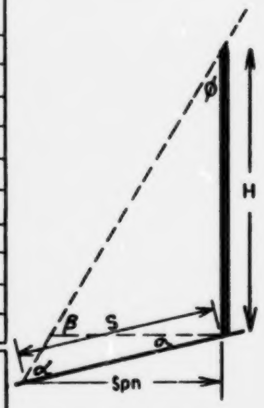
SLOPE h	$Tang^{-1}$	$\angle\sigma$	$\angle\beta$	$\angle\alpha = \angle\beta \pm \angle\sigma$	$\angle\phi$	$\sin\phi$	$\sin\alpha$	$S = \frac{H \cdot \sin\phi}{\sin\alpha}$	$\cos\sigma$	Sps or Spn
0 %	0·00	0° 00' 00"	14° 36'	14° 36' 00"	75° 24'	0.9677092	0.2520694	3.8390	1·000 0000	Sp 3.839
1 %	0·01	0° 34' 20"	"	15 10 20	"	"	0.2617213	3.6974	0·999 9501	Sps 3.697
				14 1 40			0.2423923	3.9923		Spn 3.992
2 %	0·02	1° 08' 40"	"	15 44 40	"	"	0.2713471	3.5663	0·999 8005	Sps 3.566
				13 27 20			0.2326910	4.1588		Spn 4.158
3 %	0·03	1° 43' 10"	"	16 19 10	"	"	0.2809924	3.4439	0·999 5497	Sps 3.442
				12 52 50			0.2229193	4.3411		Spn 4.340
4 %	0·04	2° 17' 30"	"	16 53 30	"	"	0.2905630	3.3305	0·999 2002	Sps 3.328
				12 18 30			0.2131725	4.5396		Spn 4.536
5 %	0·05	2° 51' 40"	"	17 27 40	"	"	0.3000584	3.2251	0·998 7535	Sps 3.221
				11 44 20			0.2034519	4.7564		Spn 4.750



(Southern Slope)

hours 10:00 & 14:00

SLOPE h	$Tang^{-1}$	$\angle\sigma$	$\angle\beta$	$\angle\alpha = \angle\beta \pm \angle\sigma$	$\angle\phi$	$\sin\phi$	$\sin\alpha$	$S = \frac{H \cdot \sin\phi}{\sin\alpha}$	$\cos\sigma$	Sps or Spn
0 %	0·00	0° 00' 00"	21° 12'	21° 12' 00"	68° 48'	0.9323238	0.3616246	2.5782	1·000 0000	Sp 2.578
1 %	0·01	0° 34' 20"	"	21 46 20	"	"	0.3709176	2.5162	0·999 9501	Sps 2.516
				20 37 40			0.3522954	2.6464		Spn 2.646
2 %	0·02	1° 08' 40"	"	22 20 40	"	"	0.3801737	2.4524	0·999 8005	Sps 2.452
				20 3 20			0.3429311	2.7187		Spn 2.718
3 %	0·03	1° 43' 10"	"	22 55 10	"	"	0.3894365	2.3940	0·999 5497	Sps 2.393
				19 28 50			0.3334869	2.7957		Spn 2.794
4 %	0·04	2° 17' 30"	"	23 29 30	"	"	0.3986157	2.3389	0·999 2002	Sps 2.337
				18 54 30			0.3240550	2.8770		Spn 2.875
5 %	0·05	2° 51' 40"	"	24 3 40	"	"	0.4077108	2.2867	0·998 7535	Sps 2.284
				18 20 20			0.3146368	2.9632		Spn 2.953



(Northern Slope)

hours 12:00

SLOPE h	$Tang^{-1}$	$\angle\sigma$	$\angle\beta$	$\angle\alpha = \angle\beta \pm \angle\sigma$	$\angle\phi$	$\sin\phi$	$\sin\alpha$	$S = \frac{H \cdot \sin\phi}{\sin\alpha}$	$\cos\sigma$	Sps or Spn
0 %	0·00	0° 00' 00"	27° 00'	27° 00' 00"	63° 00'	0.8910065	0.4539905	1.9626	1·000 0000	Sp 1.962
1 %	0·01	0° 34' 20"	"	27 34 20	"	"	0.4628663	1.9250	0·999 9501	Sps 1.925
				26 25 40			0.4450694	2.0019		Spn 2.001
2 %	0·02	1° 08' 40"	"	28 8 40	"	"	0.4716960	1.8889	0·999 8005	Sps 1.888
				25 51 20			0.4361039	2.0431		Spn 2.043
3 %	0·03	1° 43' 10"	"	28 43 10	"	"	0.4805211	1.8543	0·999 5497	Sps 1.854
				25 16 50			0.4270510	2.0864		Spn 2.085
4 %	0·04	2° 17' 30"	"	29 17 30	"	"	0.4892556	1.8211	0·999 2002	Sps 1.820
				24 42 30			0.4179992	2.1316		Spn 2.130
5 %	0·05	2° 51' 40"	"	29 51 40	"	"	0.4978992	1.7895	0·998 7535	Sps 1.787
				24 8 20			0.4089499	2.1788		Spn 2.176

FORMULA

$\angle\alpha = \angle\beta \pm \angle\sigma$

$S = \frac{H \cdot \sin\phi}{\sin\alpha}$

Sps or Spn = $S \cdot \cos\sigma$

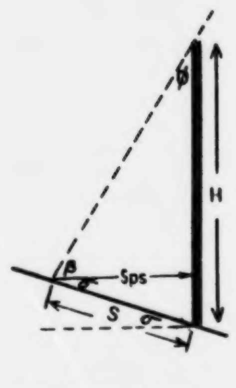
For Slopes h >5%

Sps or Spn = $\frac{100 \cdot S}{\sqrt{100^2 + h^2}}$

Date FEBRUARY 21

hours 09:00 & 15:00

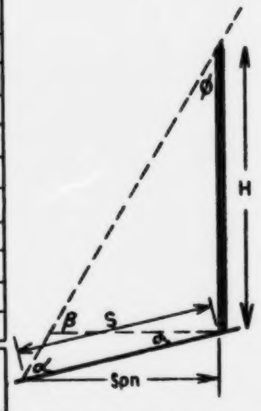
SLOPE h	Tang⁻¹	∠σ	∠β	∠α = ∠β ± ∠σ	∠φ	Sin φ	Sin α	$S=\frac{H\cdot \sin\phi}{\sin\alpha}$	Cos σ	Sps or Spn
0 %	0·00	0° 00' 00"	22° 18'	22° 18' 00"	67° 42'	0.9252097	0.3794562	2.4383	1·000 0000	Sp 2.438
1 %	0·01	0° 34' 20"	"	22 52 20	"	"	0.3886773	2.3804	0·999 9501	Sps 2.380
				21 43 40			0.3701792	2.4992		Spn 2.499
2 %	0·02	1° 08' 40"	"	23 26 40	"	"	0.3978597	2.3255	0·999 8005	Sps 2.320
				21 9 20			0.3609013	2.5636		Spn 2.563
3 %	0·03	1° 43' 10"	"	24 1 10	"	"	0.4070466	2.2730	0·999 5497	Sps 2.272
				20 34 50			0.3515240	2.6320		Spn 2.631
4 %	0·04	2° 17' 30"	"	24 35 30	"	"	0.4161485	2.2233	0·999 2002	Sps 2.222
				20 0 30			0.3421568	2.7040		Spn 2.702
5 %	0·05	2° 51' 40"	"	25 9 40	"	"	0.4251651	2.1761	0·998 7535	Sps 2.173
				19 26 20			0.3328013	2.7801		Spn 2.777



(Southern Slope)

hours 10:00 & 14:00

SLOPE h	Tang⁻¹	∠σ	∠β	∠α = ∠β ± ∠σ	∠φ	Sin φ	Sin α	$S=\frac{H\cdot \sin\phi}{\sin\alpha}$	Cos σ	Sps or Spn
0 %	0·00	0° 00' 00"	29° 36'	29° 36' 00"	60° 24'	0.8694949	0.4939419	1.7603	1·000 0000	Sp 1.760
1 %	0·01	0° 34' 20"	"	30 10 20	"	"	0.5026009	1.7300	0·999 9501	Sps 1.729
				29 1 40			0.4852336	1.7919		Spn 1.792
2 %	0·02	1° 08' 40"	"	30 44 40	"	"	0.5112098	1.7009	0·999 8005	Sps 1.701
				28 27 20			0.4764769	1.8248		Spn 1.824
3 %	0·03	1° 43' 10"	"	31 19 10	"	"	0.5198091	1.6727	0·999 5497	Sps 1.672
				27 52 50			0.4676299	1.8593		Spn 1.858
4 %	0·04	2° 17' 30"	"	31 53 30	"	"	0.5283149	1.6458	0·999 2002	Sps 1.644
				27 18 30			0.4587788	1.8952		Spn 1.894
5 %	0·05	2° 51' 40"	"	32 27 40	"	"	0.5367270	1.6200	0·998 7535	Sps 1.618
				27 44 20			0.4654429	1.8681		Spn 1.866



(Northern Slope)

hours 12:00

SLOPE h	Tang⁻¹	∠σ	∠β	∠α = ∠β ± ∠σ	∠φ	Sin φ	Sin α	$S=\frac{H\cdot \sin\phi}{\sin\alpha}$	Cos σ	Sps or Spn
0 %	0·00	0° 00' 00"	36° 12'	36° 12' 00"	53° 48'	0.8069603	0.5906057	1.3663	1·000 0000	Sp 1.366
1 %	0·01	0° 34' 20"	"	36 46 20	"	"	0.5986353	1.3480	0·999 9501	Sps 1.348
				35 37 40			0.5825171	1.3849		Spn 1.385
2 %	0·02	1° 08' 40"	"	37 20 40	"	"	0.6066053	1.3303	0·999 8005	Sps 1.330
				35 3 20			0.5743704	1.4049		Spn 1.405
3 %	0·03	1° 43' 10"	"	37 55 10	"	"	0.6145530	1.3131	0·999 5497	Sps 1.313
				34 28 50			0.5661265	1.4254		Spn 1.425
4 %	0·04	2° 17' 30"	"	38 29 30	"	"	0.6224008	1.2965	0·999 2002	Sps 1.296
				33 54 30			0.5578658	1.4465		Spn 1.445
5 %	0·05	2° 51' 40"	"	39 3 40	"	"	0.6301489	1.2806	0·998 7535	Sps 1.279
				33 20 20			0.5495900	1.4683		Spn 1.467

FORMULA

∠α = ∠β ± ∠σ

$S = \frac{H\cdot \sin\phi}{\sin\alpha}$

Sps or Spn = S·COS σ

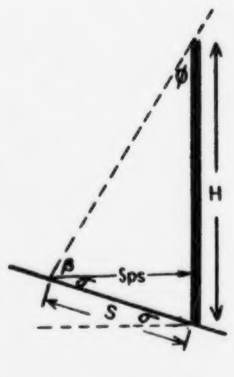
For Slopes h > 5%

$Sps \text{ or } Spn = \frac{100\cdot S}{\sqrt{100^2 + h^2}}$

Date MARCH 21

hours 09:00&15:00

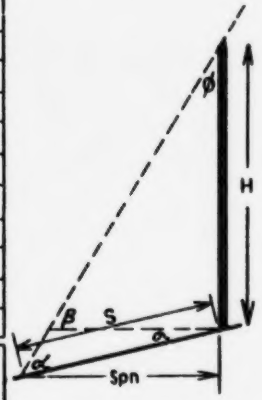
SLOPE h	$Tang^{-1}$	∠σ	∠β	∠α = ∠β ± ∠σ	∠φ	Sin φ	Sin α	S = H·Sin φ / Sin α	Cos σ	Sps or Spn
0 %	0·00	0° 00' 00"	31° 06'	31° 6' 00"	58° 54'	0.8562671	0.5165333	1.6577	1·000 0000	Sp 1.657
1 %	0·01	0° 34' 20"	"	31 40 20	"	"	0.5250591	1.6308	0·999 9501	Sps 1.630
				30 31 40			0.5079560	1.6857		Spn 1.686
2 %	0·02	1° 08' 40"	"	32 14 40	"	"	0.5335325	1.6049	0·999 8005	Sps 1.605
				29 57 20			0.4993281	1.7148		Spn 1.714
3 %	0·03	1° 43' 10"	"	32 49 10	"	"	0.5419934	1.5798	0·999 5497	Sps 1.579
				29 22 50			0.4906081	1.7453		Spn 1.744
4 %	0·04	2° 17' 30"	"	33 23 30	"	"	0.5503593	1.5558	0·999 2002	Sps 1.554
				28 48 30			0.4818811	1.7769		Spn 1.776
5 %	0·05	2° 51' 40"	"	33 57 40	"	"	0.5586301	1.5328	0·998 7535	Sps 1.530
				28 14 20			0.4731488	1.8097		Spn 1.807



(Southern Slope)

hours 10:00&14:00

SLOPE h	$Tang^{-1}$	∠σ	∠β	∠α = ∠β ± ∠σ	∠φ	Sin φ	Sin α	S = H·Sin φ / Sin α	Cos σ	Sps or Spn
0 %	0·00	0° 00' 00"	39° 18'	39° 18' 00"	50° 42'	0.7738402	0.6333809	1.2218	1·000 0000	Sp 1.221
1 %	0·01	0° 34' 20"	"	39 52 20	"	"	0.6410776	1.2071	0·999 9501	Sps 1.207
				38 43 40			0.6256209	1.2369		Spn 1.237
2 %	0·02	1° 08' 40"	"	40 26 40	"	"	0.6487104	1.1929	0·999 8005	Sps 1.193
				38 9 20			0.6177986	1.2526		Spn 1.252
3 %	0·03	1° 43' 10"	"	41 1 10	"	"	0.6563151	1.1791	0·999 5497	Sps 1.179
				37 34 50			0.6098762	1.2688		Spn 1.268
4 %	0·04	2° 17' 30"	"	41 35 30	"	"	0.6638174	1.1657	0·999 2002	Sps 1.164
				37 0 30			0.6019312	1.2856		Spn 1.285
5 %	0·05	2° 51' 40"	"	42 9 40	"	"	0.6712176	1.1529	0·998 7535	Sps 1.152
				36 26 20			0.5939651	1.3028		Spn 1.301



(Northern Slope)

hours 12:00

SLOPE h	$Tang^{-1}$	∠σ	∠β	∠α = ∠β ± ∠σ	∠φ	Sin φ	Sin α	S = H·Sin φ / Sin α	Cos σ	Sps or Spn
0 %	0·00	0° 00' 00"	47° 00'	47' 00' 00"	43° 00'	0.6819984	0.7313537	0.9325	1·000 0000	Sp 0.932
1 %	0·01	0° 34' 20"	"	47 34 20	"	"	0.7381283	0.9240	0·999 9501	Sps 0.924
				46 25 40			0.7245061	0.9413		Spn 0.941
2 %	0·02	1° 08' 40"	"	48 8 40	"	"	0.7448294	0.9156	0·999 8005	Sps 0.915
				45 51 10			0.7175863	0.9504		Spn 0.950
3 %	0·03	1° 43' 10"	"	48 43 10	"	"	0.7514881	0.9075	0·999 5497	Sps 0.907
				45 16 50			0.7105607	0.9598		Spn 0.959
4 %	0·04	2° 17' 30"	"	49 17 30	"	"	0.7580395	0.8997	0·999 2002	Sps 0.899
				44 42 30			0.7033947	0.9696		Spn 1.969
5 %	0·05	2° 51' 40"	"	49 51 40	"	"	0.7644840	0.8921	0·998 7535	Sps 0.891
				44 8 20			0.6964001	0.9793		Spn 0.978

FORMULA

$\angle\alpha = \angle\beta \pm \angle\sigma$

$S = \frac{H \cdot Sin\,\phi}{Sin\,\alpha}$

Sps or Spn = $S \cdot COS\,\sigma$

For Slopes h >5%

Sps or Spn = $\frac{100 \cdot S}{\sqrt{100^2 + h^2}}$

Date APRIL 21

hours 09:00 & 15:00

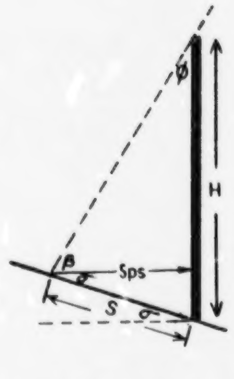
SLOPE h	Tang $^{-1}$	$\angle\sigma$	$\angle\beta$	$\angle\alpha = \angle\beta \pm \angle\sigma$	$\angle\phi$	Sin ϕ	Sin α	$S = \frac{H \cdot \sin\phi}{\sin\alpha}$	Cos σ	Sps or Spn
0 %	0·00	0° 00' 00"	40° 6'	40° 6' 00"	49° 54'	0.7649214	0.6441236	1.1875	1·000 0000	Sp 1.187
1 %	0·01	0° 34' 20"	"	40 40 20	"	"	0.6517308	1.1737	0·999 9501	Sps 1.173
				39 31 40			0.6364522	1.2018		Spn 1.201
2 %	0·02	1° 08' 40"	"	31 14 40	"	"	0.6592729	1.1602	0·999 8005	Sps 1.160
				38 57 20			0.6287174	1.2166		Spn 1.216
3 %	0·03	1° 43' 10"	"	41 49 10	"	"	0.6667854	1.1472	0·999 5497	Sps 1.147
				38 22 50			0.6208818	1.2320		Spn 1.231
4 %	0·04	2° 17' 30"	"	42 23 30	"	"	0.6741950	1.1345	0·999 2002	Sps 1.134
				37 48 30			0.6130220	1.2478		Spn 1.247
5 %	0·05	2° 51' 40"	"	42 57 40	"	"	0.6815018	1.1224	0·998 7535	Sps 1.121
				37 14 20			0.6051396	1.2640		Spn 1.262

hours 10:00 & 14:00

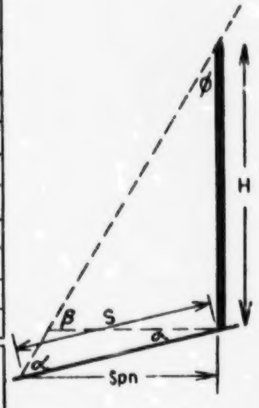
SLOPE h	Tang $^{-1}$	$\angle\sigma$	$\angle\beta$	$\angle\alpha = \angle\beta \pm \angle\sigma$	$\angle\phi$	Sin ϕ	Sin α	$S = \frac{H \cdot \sin\phi}{\sin\alpha}$	Cos σ	Sps or Spn
0 %	0·00	0° 00' 00"	49° 27'	49° 27' 00"	40° 33'	0.6501114	0.7598389	0.8556	1·000 0000	Sp 0.860
1 %	0·01	0° 34' 20"	"	50 1 20	"	"	0.7662937	0.8484	0·999 9501	Sps 0.848
				48 52 40			0.7533084	0.8630		Spn 0.863
2 %	0·02	1° 08' 40"	"	50 35 40	"	"	0.7726720	0.8414	0·999 8005	Sps 0.841
				48 18 20			0.7467027	0.8706		Spn 0.870
3 %	0·03	1° 43' 10"	"	51 10 10	"	"	0.7740037	0.8399	0·999 5497	Sps 0.839
				47 43 10			0.7399899	0.8785		Spn 0.878
4 %	0·04	2° 17' 30"	"	51 44 30	"	"	0.7852269	0.8279	0·999 2002	Sps 0.827
				47 9 30			0.7332356	0.8866		Spn 0.887
5 %	0·05	2° 51' 40"	"	52 18 40	"	"	0.7913431	0.8215	0·998 7535	Sps 0.820
				46 35 20			0.7264414	0.8949		Spn 0.894

hours 12:00

SLOPE h	Tang $^{-1}$	$\angle\sigma$	$\angle\beta$	$\angle\alpha = \angle\beta \pm \angle\sigma$	$\angle\phi$	Sin ϕ	Sin α	$S = \frac{H \cdot \sin\phi}{\sin\alpha}$	Cos σ	Sps or Spn
0 %	0·00	0° 00' 00"	58° 36'	58° 36' 00"	31° 24'	0.5210096	0.8535508	0.6104	1·000 0000	Sp 0.610
1 %	0·01	0° 34' 20"	"	59 10 20	"	"	0.8587116	0.6067	0·999 9501	Sps 0.607
				58 3 40			0.8486218	0.6139		Spn 0.614
2 %	0·02	1° 08' 40"	"	59 44 40	"	"	0.8637867	0.6032	0·999 8005	Sps 0.603
				57 27 20			0.8429744	0.6181		Spn 0.618
3 %	0·03	1° 43' 10"	"	60 19 10	"	"	0.8687996	0.5997	0·999 5497	Sps 0.599
				56 52 50			0.8375333	0.62207		Spn 0.621
4 %	0·04	2° 17' 30"	"	60 53 30	"	"	0.8737015	0.5963	0·999 2002	Sps 0.596
				56 18 30			0.8320348	0.6262		Spn 0.625
5 %	0·05	2° 51' 40"	"	61 27 40	"	"	0.8784930	0.5931	0·998 7535	Sps 0.592
				55 44 20			0.8264806	0.6304		Spn 0.630



(Southern Slope)



(Northern Slope)

FORMULA:

$\angle\alpha = \angle\beta \pm \angle\sigma$

$S = \frac{H \cdot \sin\phi}{\sin\alpha}$

Sps or Spn = $S \cdot \cos\sigma$

For Slopes h > 5%

Sps or Spn = $\frac{100 \cdot S}{\sqrt{100^2 + h^2}}$

Date MAY 21

hours 09:00&15:00

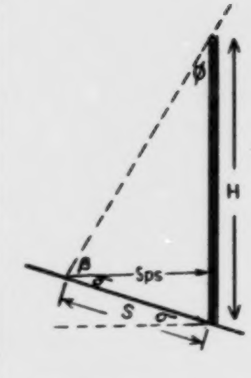
SLOPE h	Tang⁻¹	∠σ	∠β	∠α = ∠β ± ∠σ	∠φ	Sin φ	Sin α	S = H·Sin φ / Sin α	Cos σ	Sps or Spn
0 %	0·00	0° 00' 00"	46° 00'	46° 00' 00"	44° 00'	0.6946584	0.7193398	0.9657	1·000 0000	Sp 0.965
1 %	0·01	0° 34' 20"	"	46 34 20	"	"	0.7262415	0.9565	0·999 9501	Sps 0.956
				45 25 40			0.7123664	0.9751		Spn 0.975
2 %	0·02	1° 08' 40"	"	47 8 40	"	"	0.7330707	0.9476	0·999 8005	Sps 0.947
				44 51 20			0.7053219	0.9849		Spn 0.984
3 %	0·03	1° 43' 10"	"	47 43 10	"	"	0.7398595	0.9389	0·999 5497	Sps 0.939
				44 16 50			0.6981724	0.8950		Spn 0.994
4 %	0·04	2° 17' 30"	"	48 17 30	"	"	0.7465414	0.9305	0·999 2002	Sps 0.930
				43 42 30			0.6909876	1.0053		Spn 1.004
5 %	0·05	2° 51' 40"	"	48 51 40	"	"	0.7531170	0.9224	0·998 7535	Sps 0.921
				43 8 20			0.6837692	1.0159		Spn 1.015

hours 10:00&14:00

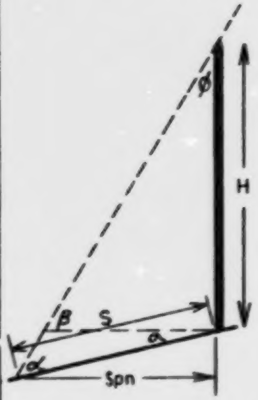
SLOPE h	Tang⁻¹	∠σ	∠β	∠α = ∠β ± ∠σ	∠φ	Sin φ	Sin α	S = H·Sin φ / Sin α	Cos σ	Sps or Spn
0 %	0·00	0° 00' 00"	55° 54'	55° 54' 00"	34° 06'	0.5606390	0.8280603	0.6770	1·000 0000	Sp 0.677
1 %	0·01	0° 34' 20"	"	56 28 20	"	"	0.8336181	0.6725	0·999 9501	Sps 0.672
				55 19 40			0.8224199	0.6817		Spn 0.682
2 %	0·02	1° 08' 40"	"	57 02 40	"	"	0.8390928	0.6681	0·999 8005	Sps 0.668
				54 45 20			0.8166975	0.6864		Spn 0.686
3 %	0·03	1° 43' 10"	"	57 37 10	"	"	0.8445097	0.6639	0·999 5497	Sps 0.664
				54 10 50			0.8108653	0.6914		Spn 0.691
4 %	0·04	2° 17' 30"	"	58 11 30	"	"	0.8498160	0.6597	0·999 2002	Sps 0.659
				53 36 30			0.8049801	0.6964		Spn 0.696
5 %	0·05	2° 51' 40"	"	58 45 40	"	"	0.8440125	0.6557	0·998 7535	Sps 0.655
				53 2 20			0.7990438	0.7016		Spn 0.701

hours 12:00

SLOPE h	Tang⁻¹	∠σ	∠β	∠α = ∠β ± ∠σ	∠φ	Sin φ	Sin α	S = H·Sin φ / Sin α	Cos σ	Sps or Spn
0 %	0·00	0° 00' 00"	67° 00'	67° 00' 00"	23° 00'	0.3907311	0.9205049	0.4245	1·000 0000	Sp 0.424
1 %	0·01	0° 34' 20"	"	67 34 20	"	"	0.9243612	0.4227	0·999 9501	Sps 0.423
				66 25 40			0.9165567	0.4263		Spn 0.426
2 %	0·02	1° 08' 40"	"	68 8 40	"	"	0.9281253	0.4210	0·999 8005	Sps 0.421
				65 51 20			0.9125172	0.4282		Spn 0.428
3 %	0·03	1° 43' 10"	"	68 43 10	"	"	0.9318145	0.4193	0·999 5497	Sps 0.419
				65 16 50			0.9083663	0.4301		Spn 0.430
4 %	0·04	2° 17' 30"	"	69 17 30	"	"	0.9353926	0.4177	0·999 2002	Sps 0.417
				64 42 30			0.9041447	0.4321		Spn 0.432
5 %	0·05	2° 51' 40"	"	69 51 40	"	"	0.9388608	0.41676	0·998 7535	Sps 0.416
				64 8 20			0.8998540	0.4342		Spn 0.434



(Southern Slope)



(Northern Slope)

FORMULA

$\angle\alpha = \angle\beta \pm \angle\sigma$

$S = \frac{H \cdot \sin\phi}{\sin\alpha}$

Sps or Spn = $S \cdot \cos\sigma$

For Slopes h > 5%

Sps or Spn = $\frac{100 \cdot S}{\sqrt{100^2 + h^2}}$

Date JUNE 21

hours 09:00 & 15:00

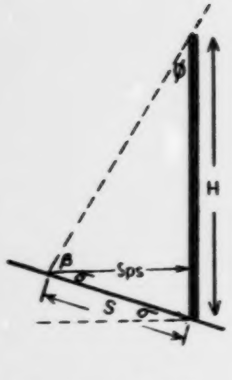
SLOPE h	$Tang^{-1}$	$\angle\sigma$	$\angle\beta$	$\angle\alpha = \angle\beta \pm \angle\sigma$	$\angle\phi$	$\sin\phi$	$\sin\alpha$	$S=\frac{H\cdot\sin\phi}{\sin\alpha}$	$\cos\sigma$	Sps or Spn
0 %	0·00	0° 00' 00"	48° 12'	48°12' 00"	41° 48'	0.6665325	0.7454760	0.8941	1·000 0000	Sp 0.894
1 %	0·01	0° 34' 20"	"	48 46 20 47 37 40	"	"	0.7520955 0.7387822	0.8862 0.9022	0·999 9501	Sps 0.886 Spn 0.902
2 %	0·02	1° 08' 40"	"	49 20 40 47 3 20	"	"	0.7586399 0.7320146	0.8786 0.9105	0·999 8005	Sps 0.878 Spn 0.910
3 %	0·03	1° 43' 10"	"	49 55 10 46 28 50	"	"	0.7651400 0.7251073	0.8711 0.9187	0·999 5497	Sps 0.981 Spn 0.918
4 %	0·04	2° 17' 30"	"	50 29 30 45 54 30	"	"	0.7715321 0.7182275	0.8639 0.9280	0·999 2002	Sps 0.863 Spn 0.927
5 %	0·05	2° 51' 40"	"	51 3 40 45 20 20	"	"	0.7778167 0.7112767	0.8569 0.0371	0·998 7535	Sps 0.857 Spn 0.936

hours 10:00 & 14:00

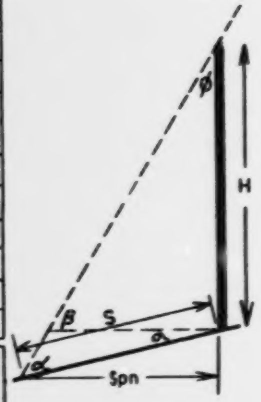
SLOPE h	$Tang^{-1}$	$\angle\sigma$	$\angle\beta$	$\angle\alpha = \angle\beta \pm \angle\sigma$	$\angle\phi$	$\sin\phi$	$\sin\alpha$	$S=\frac{H\cdot\sin\phi}{\sin\alpha}$	$\cos\sigma$	Sps or Spn
0 %	0·00	0° 00' 00"	58° 30'	58° 30' 00"	31°30'	0.5224986	0.8526402	0.6128	1·000 0000	Sp 0.612
1 %	0·01	0° 34' 20"	"	59 4 20 57 55 40	"	"	0.8578158 0.8473795	0.6091 0.6166	0·999 9501	Sps 0.609 Spn 0.617
2 %	0·02	1° 08' 40"	"	59 38 40 57 21 20	"	"	0.8629059 0.8420342	0.6055 0.6205	0·999 8005	Sps 0.605 Spn 0.620
3 %	0·03	1° 43' 10"	"	60 13 10 56 46 50	"	"	0.8679341 0.8365784	0.6020 0.6246	0·999 5497	Sps 0.601 Spn 0.624
4 %	0·04	2° 17' 30"	"	60 47 30 56 12 30	"	"	0.8728511 0.8310654	0.5986 0.6287	0·999 2002	Sps 0.598 Spn 0.628
5 %	0·05	2° 51' 40"	"	61 21 40 55 38 20	"	"	0.8776579 0.8254968	0.5953 0.6329	0·998 7535	Sps 0.594 Spn 0.632

hours 12:00

SLOPE h	$Tang^{-1}$	$\angle\sigma$	$\angle\beta$	$\angle\alpha = \angle\beta \pm \angle\sigma$	$\angle\phi$	$\sin\phi$	$\sin\alpha$	$S=\frac{H\cdot\sin\phi}{\sin\alpha}$	$\cos\sigma$	Sps or Spn
0 %	0·00	0° 00' 00"	70° 24'	70° 24' 00"	19° 36'	0.3354516	0.9420575	0.3561	1·000 0000	Sp 0.356
1 %	0·01	0° 34' 20"	"	70 58 20 69 49 40	"	"	0.9453606 0.9386603	0.3548 0.3574	0·999 9501	Sps 0.354 Spn 0.357
2 %	0·02	1° 08' 40"	"	71 32 40 69 15 20	"	"	0.9485695 0.9351696	0.3536 0.3587	0·999 8005	Sps 0.353 Spn 0.358
3 %	0·03	1° 43' 10"	"	72 7 10 68 40 50	"	"	0.9516987 0.9315679	0.3525 0.3601	0·999 5497	Sps 0.352 Spn 0.360
4 %	0·04	2° 17' 30"	"	72 41 30 68 6 30	"	"	0.9547175 0.9278905	0.3514 0.3615	0·999 2002	Sps 0.351 Spn 0.361
5 %	0·05	2° 51' 40"	"	73 15 40 67 32 20	"	"	0.9576272 0.9241391	0.3503 0.3630	0·998 7535	Sps 0.350 Spn 0.363



(Southern Slope)



(Northern Slope)

FORMULA

$\angle\alpha = \angle\beta \pm \angle\sigma$

$S = \frac{H\cdot\sin\phi}{\sin\alpha}$

Sps or Spn = S·COS σ

For Slopes h >5%

Sps or Spn = $\frac{100\cdot S}{\sqrt{100^2 + h^2}}$

Date JULY 21

hours 09:00 & 15:00

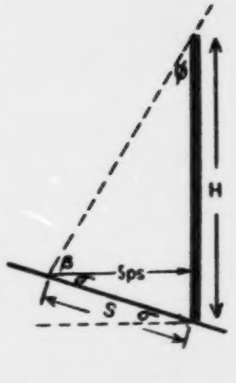
SLOPE h	$Tang^{-1}$	$\angle\sigma$	$\angle\beta$	$\angle\alpha = \angle\beta \pm \angle\sigma$	$\angle\phi$	$Sin\ \phi$	$Sin\ \alpha$	$S = \frac{H \cdot Sin\ \phi}{Sin\ \alpha}$	$Cos\ \sigma$	Sps or Spn
0 %	0·00	0° 00' 00"	46° 24'	46° 24' 00"	43° 36'	0.6896195	0.7241719	0.9522	1·000 0000	Sp 0.952
1 %	0·01	0° 34' 20"	"	46 58 20	"	"	0.7310230	0.9437	0·999 9501	Sps 0.944
				45 49 40			0.7172485	0.9615		Spn 0.961
2 %	0·02	1° 08' 40"	"	47 32 40	"	"	0.7378012	0.9347	0·999 8005	Sps 0.935
				45 15 20			0.7102536	0.9709		Spn 0.971
3 %	0·03	1° 43' 10"	"	48 7 10	"	"	0.7445381	0.9262	0·999 5497	Sps 0.926
				44 40 50			0.7031534	0.9807		Spn 0.980
4 %	0·04	2° 17' 30"	"	48 41 30	"	"	0.7511681	0.9181	0·999 2002	Sps 0.917
				44 6 30			0.6960172	0.9908		Spn 0.990
5 %	0·05	2° 51' 40"	"	49 15 40	"	"	0.7576916	0.9102	0·998 7535	Sps 0.909
				43 32 20			0.6888468	1.0011		Spn 0.999

hours 10:00 & 14:00

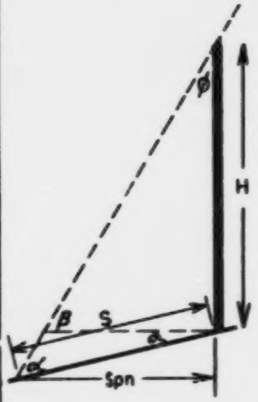
SLOPE h	$Tang^{-1}$	$\angle\sigma$	$\angle\beta$	$\angle\alpha = \angle\beta \pm \angle\sigma$	$\angle\phi$	$Sin\ \phi$	$Sin\ \alpha$	$S = \frac{H \cdot Sin\ \phi}{Sin\ \alpha}$	$Cos\ \sigma$	Sps or Spn
0 %	0·00	0° 00' 00"	56° 24'	56° 24' 00"	33° 36'	0.5333915	0.8329212	0.6644	1·000 0000	Sp 0.664
1 %	0·01	0° 34' 20"	"	56 58 20	"	"	0.8384064	0.6632	0·999 9501	Sps 0.663
				55 49 40			0.8273530	0.6689		Spn 0.669
2 %	0·02	1° 08' 40"	"	57 32 40	"	"	0.8438080	0.6558	0·999 8005	Sps 0.656
				55 15 20			0.8217022	0.6735		Spn 0.673
3 %	0·03	1° 43' 10"	"	58 7 10	"	"	0.8491510	0.6517	0·999 5497	Sps 0.651
				54 40 50			0.8159414	0.6782		Spn 0.677
4 %	0·04	2° 17' 30"	"	58 41 30	"	"	0.8543833	0.6477	0·999 2002	Sps 0.647
				54 6 30			0.8101269	0.6831		Spn 0.682
5 %	0·05	2° 51' 40"	"	59 15 40	"	"	0.8595055	0.6438	0·998 7535	Sps 0.643
				53 32 20			0.8042604	0.6881		Spn 0.687

hours 12:00

SLOPE h	$Tang^{-1}$	$\angle\sigma$	$\angle\beta$	$\angle\alpha = \angle\beta \pm \angle\sigma$	$\angle\phi$	$Sin\ \phi$	$Sin\ \alpha$	$S = \frac{H \cdot Sin\ \phi}{Sin\ \alpha}$	$Cos\ \sigma$	Sps or Spn
0 %	0·00	0° 00' 00"	67°36'	67°36' 00"	22° 24'	0.3810704	0.9245460	0.4122	1·000 0000	Sp 0.412
1 %	0·01	0° 34' 20"	"	68 10 20	"	"	0.9283057	0.4105	0·999 9501	Sps 0.410
				67 1 40			0.9206942	0.4139		Spn 0.414
2 %	0·02	1° 08' 40"	"	68 44 40	"	"	0.9319727	0.4089	0·999 8005	Sps 0.409
				66 27 20			0.9167505	0.4157		Spn 0.416
3 %	0·03	1° 43' 10"	"	69 19 10	"	"	0.9355639	0.4073	0·999 5497	Sps 0.407
				65 52 50			0.9126956	0.4175		Spn 0.417
4 %	0·04	2° 17' 30"	"	69 53 30	"	"	0.9390443	0.4058	0·999 2002	Sps 0.405
				65 18 30			0.9085689	0.4194		Spn 0.419
5 %	0·05	2° 51' 40"	"	70 27 40	"	"	0.9424147	0.4043	0·998 7535	Sps 0.404
				64 44 20			0.9043724	0.4214		Spn 0.421



(Southern Slope)



(Northern Slope)

FORMULA

$\angle\alpha = \angle\beta \pm \angle\sigma$

$S = \frac{H \cdot Sin\ \phi}{Sin\ \alpha}$

Sps or Spn = $S \cdot COS\ \sigma$

For Slopes h >5%

Sps or Spn = $\frac{100 \cdot S}{\sqrt{100^2 + h^2}}$

Date AUGUST 21

hours 09:00&15:00

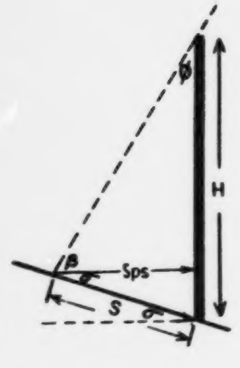
SLOPE h	$Tang^{-1}$	$\angle\sigma$	$\angle\beta$	$\angle\alpha = \angle\beta \pm \angle\sigma$	$\angle\phi$	$\sin\phi$	$\sin\alpha$	$S = \frac{H \cdot \sin\phi}{\sin\alpha}$	$\cos\sigma$	Sps or Spn
0 %	0·00	0° 00' 00"	40° 36'	40°36'00"	49° 24'	0.7592713	0.6507742	1.1667	1·000 0000	Sp 1.166
1 %	0·01	0° 34' 20"	"	41 10 20 40 1 40	"	"	0.6583246 0.6431589	1.1533 1.1805	0·999 9501	Sps 1.153 Spn 1.180
2 %	0·02	1° 08' 40"	"	41 44 40 39 27 20	"	"	0.6658093 0.6354795	1.1404 1.1948	0·999 8005	Sps 1.140 Spn 1.194
3 %	0·03	1° 43' 10"	"	42 19 10 38 52 50	"	"	0.6732635 0.6276989	1.1277 1.2096	0·999 5497	Sps 1.127 Spn 1.209
4 %	0·04	2° 17' 30"	"	42 53 30 38 18 30	"	"	0.6806143 0.6198933	1.1156 1.2248	0·999 2002	Sps 1.115 Spn 1.224
5 %	0·05	2° 51' 40"	"	43 27 40 37 44 20	"	"	0.6878621 0.6210639	1.1038 1.2405	0·998 7535	Sps 1.102 Spn 1.239

hours 10:00 & 14:00

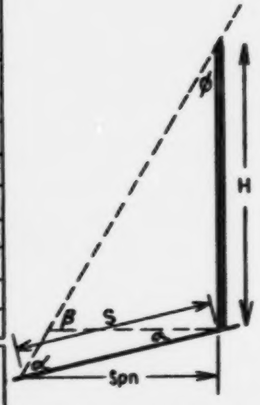
SLOPE h	$Tang^{-1}$	$\angle\sigma$	$\angle\beta$	$\angle\alpha = \angle\beta \pm \angle\sigma$	$\angle\phi$	$\sin\phi$	$\sin\alpha$	$S = \frac{H \sin\phi}{\sin\alpha}$	$\cos\sigma$	Sps or Spn
0 %	0·00	0° 00' 00"	49°48'	49° 48' 00"	40° 12'	0.6454577	0.7637960	0.8451	1·000 0000	Sp 0.845
1 %	0·01	0° 34' 20"	"	50 22 20 49 13 40	"	"	0.7702041 0.7573118	0.8380 0.8523	0·999 9501	Sps 0.838 Spn 0.852
2 %	0·02	1° 08' 40"	"	50 56 40 48 39 20	"	"	0.7765354 0.7507519	0.8312 0.8597	0·999 8005	Sps 8.831 Spn 0.859
3 %	0·03	1° 43' 10"	"	51 31 10 48 4 50	"	"	0.7828194 0.7440849	0.8245 0.8675	0·999 5497	Sps 0.824 Spn 0.867
4 %	0·04	2° 17' 30"	"	52 5 30 47 30 30	"	"	0.7889947 0.7473756	0.8181 0.8753	0·999 2002	Sps 0.817 Spn 0.875
5 %	0·05	2° 51' 40"	"	52 39 40 46 56 20	"	"	0.7950620 0.7306259	0.8118 0.8834	0·998 7535	Sps 0.811 Spn 0.882

hours 12:00

SLOPE h	$Tang^{-1}$	$\angle\sigma$	$\angle\beta$	$\angle\alpha = \angle\beta \pm \angle\sigma$	$\angle\phi$	$\sin\phi$	$\sin\alpha$	$S = \frac{H \cdot \sin\phi}{\sin\alpha}$	$\cos\sigma$	Sps or Spn
0 %	0·00	0° 00' 00"	59°18'	59°18'00"	30°42'	0.5105429	0.8498523	0.5938	1·000 0000	Sp 0.593
1 %	0·01	0° 34' 20"	"	59 52 20 58 43 40	"	"	0.8649082 0.8547106	0.5903 0.5973	0·999 9501	Sps 0.590 Spn 0.597
2 %	0·02	1° 08' 40"	"	60 26 40 58 9 20	"	"	0.8698778 0.8494837	0.5869 0.6010	0·999 8005	Sps 0.587 Spn 0.601
3 %	0·03	1° 43' 10"	"	61 1 10 57 34 50	"	"	0.8747842 0.8441460	0.5836 0.6048	0·999 5497	Sps 0.583 Spn 0.605
4 %	0·04	2° 17' 30"	"	61 35 30 57 0 30	"	"	0.8795794 0.8387498	0.5804 0.6087	0·999 2002	Sps 0.580 Spn 0.608
5 %	0·05	2° 51' 40"	"	62 9 40 56 6 20	"	"	0.8842642 0.8332967	0.5774 0.6127	0·998 7535	Sps 0.608 Spn 0.612



(Southern Slope)



(Northern Slope)

FORMULA

$\angle\alpha = \angle\beta \pm \angle\sigma$

$S = \frac{H \cdot \sin\phi}{\sin\alpha}$

Sps or Spn = $S \cdot \cos\sigma$

For Slopes h >5%

Sps or Spn = $\frac{100 \cdot S}{\sqrt{100^2 + h^2}}$

Date SEPTEMBER 21

hours 09:00&15:00

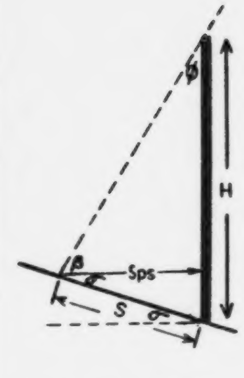
SLOPE h	Tang $^{-1}$	∠σ	∠β	∠α = ∠β ± ∠σ	∠φ	Sin φ	Sin α	S = H·Sin φ / Sin α	Cos σ	Sps or Spn
0 %	0·00	0° 00' 00"	31°06'	31°06' 00"	58°54'	0.8562671	0.5165333	1.6577	1·000 0000	Sp 1.657
1 %	0·01	0° 34' 20"	"	31 40 20	"	"	0.5250591	1.6308	0·999 9501	Sps 1.631
				30 31 40			0.5079560	1.6857		Spn 1.686
2 %	0·02	1° 08' 40"	"	32 14 40	"	"	0.5335325	1.6049	0·999 8005	Sps 1.605
				29 57 20			0.4993281	1.7148		Spn 1.714
3 %	0·03	1° 43' 10"	"	32 49 10	"	"	0.5419934	1.5799	0·999 5497	Sps 1.579
				29 22 50			0.4906081	1.7453		Spn 1.745
4 %	0·04	2° 17' 30"	"	33 23 30	"	"	0.5503593	1.5558	0·999 2002	Sps 1.555
				28 48 30			0.4814811	1.7769		Spn 1.776
5 %	0·05	2° 51' 40"	"	33 47 40	"	"	0.5586301	1.5328	0·998 7535	Sps 1.531
				28 14 20			0.4731488	1.8097		Spn 1.807

hours 10:00&14:00

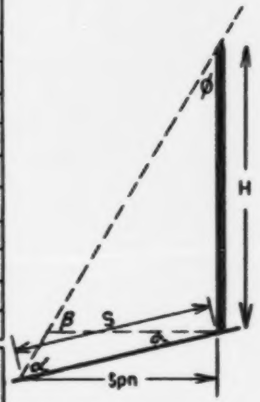
SLOPE h	Tang $^{-1}$	∠σ	∠β	∠α = ∠β ± ∠σ	∠φ	Sin φ	Sin α	S = H·Sin φ / Sin α	Cos σ	Sps or Spn
0 %	0·00	0° 00' 00"	39°18'	39°18' 00"	50°42'	0.7738402	0.6333809	1.2218	1·000 0000	Sp 1.221
1 %	0·01	0° 34' 20"	"	39 52 20	"	"	0.6410776	1.2071	0·999 9501	Sps 1.207
				38 43 40			0.6256209	1.2369		Spn 1.236
2 %	0·02	1° 08' 40"	"	40 26 40	"	"	0.6487104	1.1929	0·999 8005	Sps 1.193
				38 9 20			0.6177986	1.2526		Spn 1.252
3 %	0·03	1° 43' 10"	"	41 1 10	"	"	0.6563151	1.1791	0·999 5497	Sps 1.179
				37 34 50			0.6098762	1.2689		Spn 1.268
4 %	0·04	2° 17' 30"	"	41 35 30	"	"	0.6638174	1.1657	0·999 2002	Sps 1.165
				37 0 30			0.6019312	1.2856		Spn 1.285
5 %	0·05	2° 51' 40"	"	42 9 40	"	"	0.6712176	1.1529	0·998 7535	Sps 1.152
				36 26 20			0.5939651	1.3028		Spn 1.301

hours 12:00

SLOPE h	Tang $^{-1}$	∠σ	∠β	∠α = ∠β ± ∠σ	∠φ	Sin φ	Sin α	S = H·Sin φ / Sin α	Cos σ	Sps or Spn
0 %	0·00	0° 00' 00"	47°00'	47°00' 00"	43° 00'	0.6819984	0.7313537	0.9325	1·000 0000	Sp 0.932
1 %	0·01	0° 34' 20"	"	47 34 20	"	"	0.7381283	0.9240	0·999 9501	Sps 0.924
				46 24 40			0.7245061	0.9413		Spn 0.941
2 %	0·02	1° 08' 40"	"	48 8 40	"	"	0.7448294	0.9156	0·999 8005	Sps 0.915
				45 51 20			0.7175863	0.9504		Spn 0.950
3 %	0·03	1° 43' 10"	"	48 43 10	"	"	0.7514881	0.9075	0·999 5497	Sps 0.907
				45 16 50			0.7105607	0.9598		Spn 0.959
4 %	0·04	2° 17' 30"	"	49 17 30	"	"	0.7580395	0.8997	0·999 2002	Sps 0.899
				44 42 30			0.7034981	0.9694		Spn 0.969
5 %	0·05	2° 51' 40"	"	49 51 40	"	"	0.7644840	0.8921	0·998 7535	Sps 0.891
				44 8 20			0.6964001	0.9793		Spn 0.978



(Southern Slope)



(Northern Slope)

FORMULA

$\angle\alpha = \angle\beta \pm \angle\sigma$

$S = \frac{H \cdot \sin\phi}{\sin\alpha}$

Sps or Spn = $S \cdot \cos\sigma$

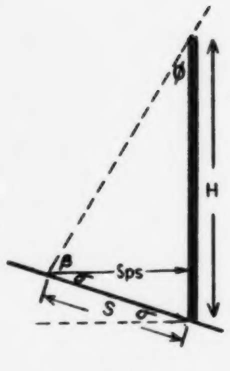
For Slopes h > 5%

Sps or Spn = $\frac{100 \cdot S}{\sqrt{100^2 + h^2}}$

Date OCTOBER 21

hours 09:00 & 15:00

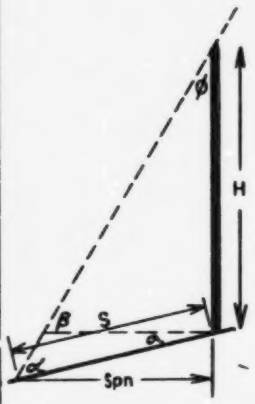
SLOPE h	$Tang^{-1}$	$\angle\sigma$	$\angle\beta$	$\angle\alpha = \angle\beta \pm \angle\sigma$	$\angle\phi$	$\sin\phi$	$\sin\alpha$	$S = \frac{H \cdot \sin\phi}{\sin\alpha}$	$\cos\sigma$	Sps or Spn
0 %	0·00	0° 00' 00"	22° 36'	22°36'00"	67°24'	0.9232102	0.3842953	2.4023	1·000 0000	Sp 2.402
1 %	0·01	0° 34' 20"	"	23 10 20 22 10 40	"	"	0.3934963 0.3750561	2.3462 2.4615	0·999 9501	Sps 2.345 Spn 2.461
2 %	0·02	1° 08' 40"	"	23 44 40 21 27 20	"	"	0.4026579 0.3657794	2.2928 2.5236	0·999 8005	Sps 2.292 Spn 2.523
3 %	0·03	1° 43' 10"	"	24 19 10 20 52 50	"	"	0.4118236 0.3564209	2.2418 2.5902	0·999 5497	Sps 2.241 Spn 2.589
4 %	0·04	2° 17' 30"	"	24 18 30 20 18 30	"	"	0.4209039 0.3470721	2.1934 2.6600	0·999 2002	Sps 2.192 Spn 2.658
5 %	0·05	2° 51' 40"	"	25 27 40 19 44 20	"	"	0.4298984 0.3377342	2.1475 2.7335	0·998 7535	Sps 2.145 Spn 2.739



(Southern Slope)

hours 10:00 & 14:00

SLOPE h	$Tang^{-1}$	$\angle\sigma$	$\angle\beta$	$\angle\alpha = \angle\beta \pm \angle\sigma$	$\angle\phi$	$\sin\phi$	$\sin\alpha$	$S = \frac{H \sin\phi}{\sin\alpha}$	$\cos\sigma$	Sps or Spn
0 %	0·00	0° 00' 00"	29°54'	29°54' 00"	60°06'	0.8668967	0.4984877	1.7391	1·000 0000	Sp 1.739
1 %	0·01	0° 34' 20"	"	30 28 20 29 19 40	"	"	0.5071206 0.4898052	1.7094 1.7699	0·999 9501	Sps 1.709 Spn 1.769
2 %	0·02	1° 08' 40"	"	31 2 40 28 45 20	"	"	0.5157028 0.4810738	1.6810 1.8020	0·999 8005	Sps 1.681 Spn 1.802
3 %	0·03	1° 43' 10"	"	31 37 10 28 10 50	"	"	0.5242749 0.4722517	1.6535 1.8357	0·999 5497	Sps 1.646 Spn 1.835
4 %	0·04	2° 17' 30"	"	32 1 30 27 36 30	"	"	0.5302892 0.4634249	1.6348 1.8706	0·999 2002	Sps 1.634 Spn 1.869
5 %	0·05	2° 51' 40"	"	32 45 40 27 2 20	"	"	0.5411376 0.4545952	1.6020 1.9060	0·998 7535	Sps 1.600 Spn 1.904



(Northern Slope)

hours 12:00

SLOPE h	$Tang^{-1}$	$\angle\sigma$	$\angle\beta$	$\angle\alpha = \angle\beta \pm \angle\sigma$	$\angle\phi$	$\sin\phi$	$\sin\alpha$	$S = \frac{H \cdot \sin\phi}{\sin\alpha}$	$\cos\sigma$	Sps or Spn
0 %	0·00	0° 00' 00"	36°30'	36°30'00"	53°30'	0.8038569	0.5948228	1.3514	1·000 0000	Sp 1.351
1 %	0·01	0° 34' 20"	"	37 3 20 35 55 40	"	"	0.6028212 0.5867650	1.3514 1.3700	0·999 9501	Sps 1.351 Spn 1.370
2 %	0·02	1° 08' 40"	"	37 38 40 35 21 20	"	"	0.6107596 0.5786487	1.3162 1.3892	0·999 8005	Sps 1.315 Spn 1.389
3 %	0·03	1° 43' 10"	"	35 13 10 34 46 50	"	"	0.6186751 0.5704349	1.2993 1.4092	0·999 5497	Sps 1.298 Spn 1.409
4 %	0·04	2° 17' 30"	"	38 47 30 34 12 30	"	"	0.6264905 0.5622037	1.2831 1.4285	0·999 2002	Sps 1.282 Spn 1.427
5 %	0·05	2° 51' 40"	"	39 21 40 33 38 20	"	"	0.6342059 0.5539568	1.2675 1.4511	0·998 7535	Sps 1.266 Spn 1.449

FORMULA

$\angle\alpha = \angle\beta \pm \angle\sigma$

$S = \frac{H \cdot \sin\phi}{\sin\alpha}$

Sps or Spn = $S \cdot \cos\sigma$

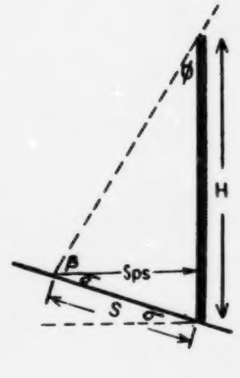
For Slopes h >5%

Sps or Spn = $\frac{100 \cdot S}{\sqrt{100^2 + h^2}}$

Date NOVEMBER 21

hours 09:00 & 15:00

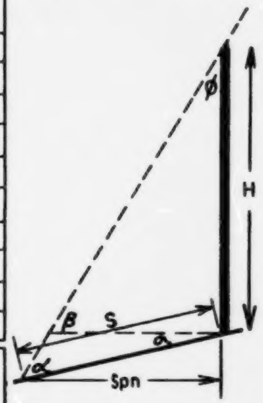
SLOPE h	$Tang^{-1}$	$\angle\sigma$	$\angle\beta$	$\angle\alpha = \angle\beta \pm \angle\sigma$	$\angle\phi$	$Sin\ \phi$	$Sin\ \alpha$	$S = \frac{H \cdot Sin\ \phi}{Sin\ \alpha}$	$Cos\ \sigma$	Sps or Spn
0 %	0·00	0° 00' 00"	14° 48'	14°18' 00"	75°12'	0.9668234	0.2554458	3.7848	1·000 0000	Sp 3.784
1 %	0·01	0° 34' 20"	"	15 22 20	"	"	0.2650887	3.6472	0·999 9501	Sps 3.647
				14 13 40			0.2457774	3.9337		Spn 3.934
2 %	0·02	1° 08' 40"	"	15 56 40	"	"	0.2747052	3.5195	0·999 8005	Sps 3.519
				13 39 20			0.2360844	4.0952		Spn 4.094
3 %	0·03	1° 43' 10"	"	16 31 10	"	"	0.2843407	3.4002	0·999 5497	Sps 3.399
				13 4 50			0.2263208	4.2719		Spn 4.270
4 %	0·04	2° 17' 30"	"	17 5 30	"	"	0.2939013	3.2896	0·999 2002	Sps 3.287
				12 30 30			0.2165816	4.6025		Spn 4.599
5 %	0·05	2° 51' 40"	"	17 39 40	"	"	0.3033864	3.1868	0·998 7535	Sps 3.183
				11 56 20			0.2068683	4.6736		Spn 4.668



(Southern Slope)

hours 10:00 & 14:00

SLOPE h	$Tang^{-1}$	$\angle\sigma$	$\angle\beta$	$\angle\alpha = \angle\beta \pm \angle\sigma$	$\angle\phi$	$Sin\phi$	$Sin\ \alpha$	$S = \frac{H \cdot Sin\phi}{Sin\alpha}$	$Cos\ \sigma$	Sps or Spn
0 %	0·00	0° 00' 00"	21° 24'	21°24' 00"	68°36'	0.9310558	0.3648768	2.5515	1·000 0000	Sp 2.551
1 %	0·01	0° 34' 20"	"	21 58 20	"	"	0.3741570	2.4883	0·999 9501	Sps 2.488
				20 49 40			0.3555601	2.6186		Spn 2.619
2 %	0·02	1° 08' 40"	"	22 32 40	"	"	0.3834000	2.4284	0·999 8005	Sps 2.428
				20 15 20			0.3462080	2.6893		Spn 2.688
3 %	0·03	1° 43' 10"	"	23 7 10	"	"	0.3926493	2.3712	0·999 5497	Sps 2.370
				19 40 50			0.3367757	2.7646		Spn 2.763
4 %	0·04	2° 17' 30"	"	23 41 30	"	"	0.4018146	2.3171	0·999 2002	Sps 2.315
				19 6 30			0.3273553	2.8442		Spn 2.842
5 %	0·05	2° 51' 40"	"	24 16 40	"	"	0.4111608	2.2644	0·998 7535	Sps 2.262
				18 32 20			0.3179482	2.9283		Spn 2.925



(Northern Slope)

hours 12:00

SLOPE h	$Tang^{-1}$	$\angle\sigma$	$\angle\beta$	$\angle\alpha = \angle\beta \pm \angle\sigma$	$\angle\phi$	$Sin\phi$	$Sin\ \alpha$	$S = \frac{H \cdot Sin\phi}{Sin\alpha}$	$Cos\ \sigma$	Sps or Spn
0 %	0·00	0° 00' 00"	37° 12'	27° 12' 00"	62° 48'	0.8894164	0.4570979	1.9457	1·000 0000	Sp 1.945
1 %	0·01	0° 34' 20"	"	27 46 20	"	"	0.4659577	1.9088	0·999 9501	Sps 1.909
				26 37 40			0.4481925	1.9844		Spn 1.984
2 %	0·02	1° 08' 40"	"	28 20 40	"	"	0.4747711	1.8733	0·999 8005	Sps 1.873
				26 3 20			0.4392424	2.0248		Spn 2.024
3 %	0·03	1° 43' 10"	"	28 55 10	"	"	0.4835795	1.8392	0·999 5497	Sps 1.838
				25 28 50			0.4302408	2.0673		Spn 2.066
4 %	0·04	2° 17' 30"	"	29 29 30	"	"	0.4922970	1.8067	0·999 2002	Sps 1.805
				24 54 30			0.4211677	2.1118		Spn 2.110
5 %	0·05	2° 51' 40"	"	30 3 40	"	"	0.5009234	1.7756	0·998 7535	Sps 1.773
				24 20 20			0.4121329	2.1581		Spn 2.156

FORMULA

$\angle\alpha = \angle\beta \pm \angle\sigma$

$S = \frac{H \cdot Sin\ \phi}{Sin\ \alpha}$

Sps or Spn = $S \cdot COS\ \sigma$

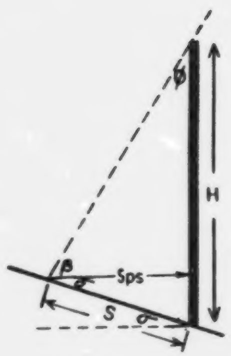
For Slopes h >5%

Sps or Spn = $\frac{100 \cdot S}{\sqrt{100^2 + h^2}}$

Date DECEMBER 21

hours 09:00 & 15:00

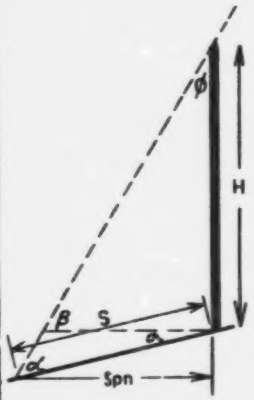
SLOPE h	Tang^{-1}	$\angle\sigma$	$\angle\beta$	$\angle\alpha = \angle\beta \pm \angle\sigma$	$\angle\phi$	Sin ϕ	Sin α	$S = \frac{H \cdot \sin\phi}{\sin\alpha}$	Cos σ	Sps or Spn
0 %	0·00	0° 00' 00"	11° 42'	11°42' 00"	78° 18'	0.979228	0.2027873	4.8288	1·000 0000	Sp 4.828
1 %	0·01	0° 34' 20"	"	12 16 20	"	"	0.2125567	4.6069	0·999 9501	Sps 4.607
				11 15 40			0.1952805	5.0144		Spn 5.014
2 %	0·02	1° 08' 40"	"	12 50 40	"	"	0.2223049	4.4049	0·999 8005	Sps 4.404
				10 33 20			0.1831888	5.3454		Spn 5.344
3 %	0·03	1° 43' 10"	"	13 25 10	"	"	0.2320780	4.2194	0·999 5497	Sps 4.218
				9 58 50			0.1733140	5.6500		Spn 5.647
4 %	0·04	2° 17' 30"	"	13 59 30	"	"	0.2417808	4.0500	0·999 2002	Sps 4.047
				9 24 30			0.1634695	5.9903		Spn 5.986
5 %	0·05	2° 51' 40"	"	14 33 40	"	"	0.2515125	3.8949	0·998 7535	Sps 3.890
				8 50 20			0.1536566	6.3728		Spn 6.365



(Southern Slope)

hours 10:00 & 14:00

SLOPE h	Tang^{-1}	$\angle\sigma$	$\angle\beta$	$\angle\alpha = \angle\beta \pm \angle\sigma$	$\angle\phi$	Sin ϕ	Sin α	$S = \frac{H \cdot \sin\phi}{\sin\alpha}$	Cos σ	Sps or Spn
0 %	0·00	0° 00' 00"	18° 00'	18° 00' 00"	&@° 00'	0.9512361	0.3090170	3.0783	1·000 0000	Sp 3.077
1 %	0·01	0° 34' 20"	"	18 34 20	"	"	0.3184998	2.9866	0·999 9501	Sps 2.986
				17 25 40			0.2995034	3.1760		Spn 3.176
2 %	0·02	1° 08' 40"	"	19 8 40	"	"	0.3279508	2.9005	0·999 8005	Sps 2.900
				16 51 20			0.2899599	3.2806		Spn 3.280
3 %	0·03	1° 43' 10"	"	19 43 10	"	"	0.3374147	2.8192	0·999 5497	Sps 2.818
				16 16 50			0.2803410	3.3931		Spn 3.392
4 %	0·04	2° 17' 30"	"	20 17 30	"	"	0.3467992	2.7429	0·999 2002	Sps 2.741
				15 42 30			0.2707405	3.5135		Spn 3.511
5 %	0·05	2° 51' 40"	"	20 51 40	"	"	0.3561038	2.6710	0·998 7535	Sps 2.669
				15 8 20			0.2611598	3.6423		Spn 3.638



(Northern Slope)

hours 12:00

SLOPE h	Tang^{-1}	$\angle\sigma$	$\angle\beta$	$\angle\alpha = \angle\beta \pm \angle\sigma$	$\angle\phi$	Sin ϕ	Sin α	$S = \frac{H \cdot \sin\phi}{\sin\alpha}$	Cos σ	Sps or Spn
0 %	0·00	0° 00' 00"	23° 36'	23° 36' 00"	66°24'	0.9163627	0.4003490	2.2885	1·000 0000	Sp 2.288
1 %	0·01	0° 34' 20"	"	24 10 20	"	"	0.4094808	2.2379	0·999 9501	Sps 2.238
				23 1 40			0.3911774	2.3426		Spn 2.342
2 %	0·02	1° 08' 40"	"	24 44 40	"	"	0.4185717	2.1893	0·999 8005	Sps 2.189
				22 27 20			0.3819667	2.3991		Spn 2.398
3 %	0·03	1° 43' 10"	"	25 19 10	"	"	0.4276647	2.1427	0·999 5497	Sps 2.142
				21 52 50			0.3726729	2.4589		Spn 2.458
4 %	0·04	2° 17' 30"	"	25 53 30	"	"	0.4366709	2.0985	0·999 2002	Sps 2.097
				21 18 30			0.3633867	2.5217		Spn 2.520
5 %	0·05	2° 51' 40"	"	26 27 40	"	"	0.4455903	2.0565	0·998 7535	Sps 2.054
				20 44 20			0.3541097	2.5878		Spn 2.584

FORMULA

$\angle\alpha = \angle\beta \pm \angle\sigma$

$S = \frac{H \cdot \sin\phi}{\sin\alpha}$

Sps or Spn = S·COS σ

For Slopes h > 5%

Sps or Spn = $\frac{100 \cdot S}{\sqrt{100^2 + h^2}}$

WIND SPEED AND DIRECTION HOURLY
- RECORDED FROM JANUARY, 1976 TO DECEMBER, 1979

THE WIND SPEED WAS RECORDED IN EIGHT DIRECTIONS UP TO YEAR 1975. SINCE 1976, RECORDINGS WERE EXTENDED TO SIXTEEN DIRECTIONS.

APPENDIX C

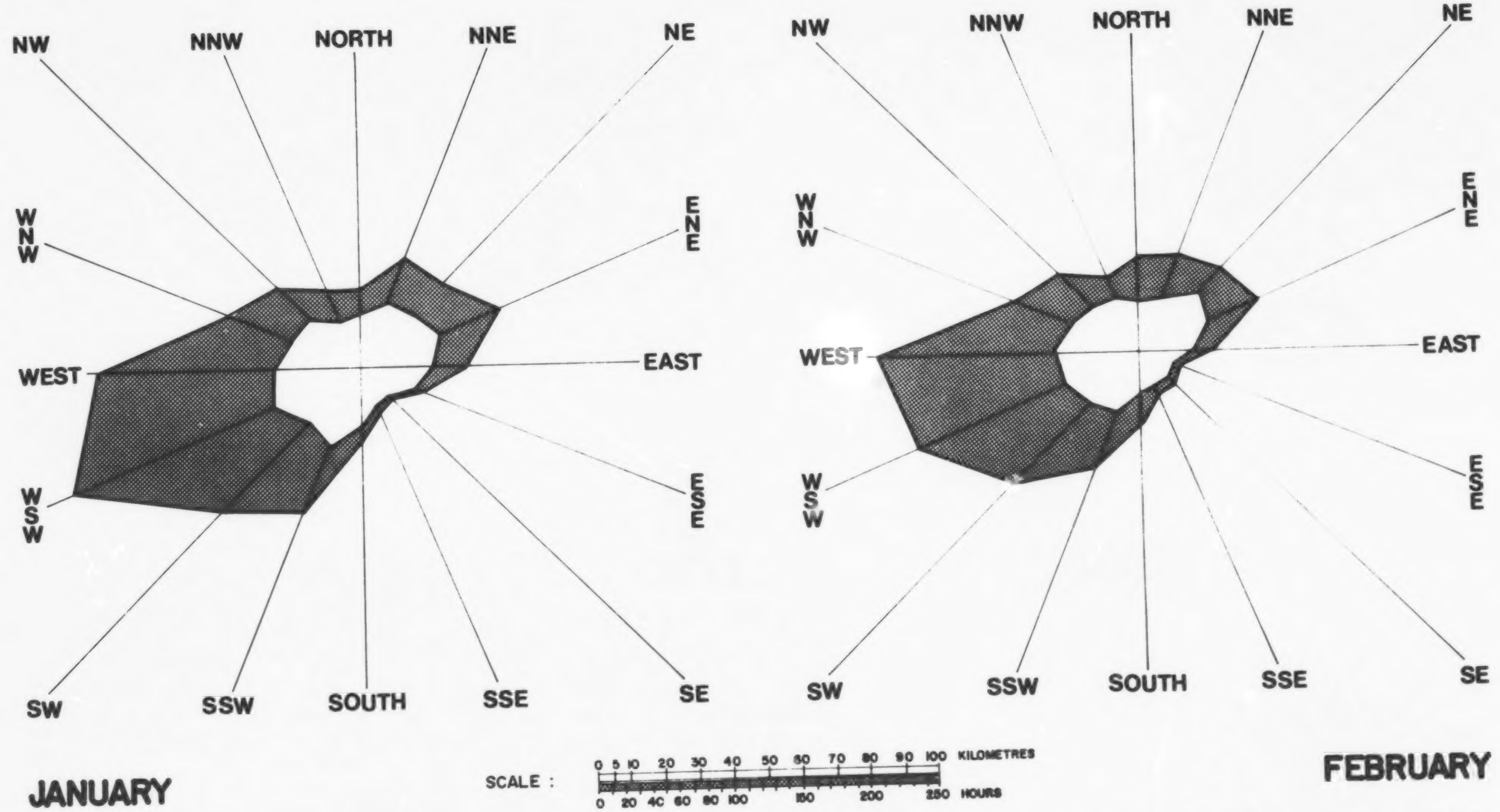
WIND SPEED(km/h), FREQUENCY & PREVAILING DIRECTION

		NORTH		NNE		NE		ENE		EAST		ESE		SE		SSE	
		SPEED	HOURS	SPEED	HOURS	SPEED	HOURS	SPEED	HOURS	SPEED	HOURS	SPEED	HOURS	SPEED	HOURS	SPEED	HOURS
JANUARY	1976	15	14	20	49	21	37	21	33	16	31	15	10	15	5	11	10
	1977	14	7	19	10	15	13	29	11	31	10	18	4	12	2	15	7
	1978	21	21	28	57	29	46	30	79	25	19	20	5	6	1	12	4
	1979	13	30	15	17	21	25	18	70	13	41	13	5	11	4	7	2
	TOTAL	63	72	82	133	86	123	98	193	85	101	66	24	44	12	45	23
	AVERAGE SPEED HOURS	16	18	21	33	22	31	25	48	21	25	17	6	11	3	11	6
FEBRUARY	1976	13	16	17	20	17	21	18	36	13	14	12	6	10	5	12	6
	1977	10	3	6	1	31	20	27	35	18	4	14	3	15	8	12	6
	1978	18	63	20	38	20	17	18	14	11	2	7	5	11	2	11	3
	1979	16	50	22	71	29	38	21	79	17	42	7	9	9	12	9	11
	TOTAL	57	132	65	130	97	96	84	164	59	62	40	23	45	27	44	26
	AVERAGE SPEED HOURS	14	33	16	33	24	24	21	41	15	16	10	6	11	7	11	7
MARCH	1976	24	5	17	12	25	79	29	91	19	15	13	13	12	8	17	12
	1977	21	13	24	5	24	65	23	66	12	29	12	9	12	13	13	15
	1978	13	19	16	28	19	51	22	76	16	36	10	4	11	7	18	9
	1979	8	5	8	18	14	87	14	77	10	41	8	10	17	10	16	32
	TOTAL	66	42	65	63	82	282	88	310	57	121	43	36	52	38	64	68
	AVERAGE SPEED HOURS	17	11	16	16	21	71	22	78	14	30	11	9	13	10	16	17
APRIL	1976	20	25	27	34	29	60	26	12	10	2	11	5	6	1	12	10
	1977	14	25	13	27	21	94	19	68	10	25	9	6	7	5	13	9
	1978	15	67	18	64	21	123	20	69	17	29	20	2	11	1	8	3
	1979	15	35	15	15	20	57	26	110	16	31	9	15	10	8	11	16
	TOTAL	64	152	73	140	91	334	91	259	53	87	49	28	34	15	44	38
	AVERAGE SPEED HOURS	16	38	18	35	23	84	23	65	13	22	12	7	9	4	11	10
MAY	1976	15	19	19	30	17	121	17	48	11	10	8	10	9	5	15	18
	1977	20	42	17	57	17	89	24	46	16	16	9	4	17	2	12	22
	1978	13	23	19	73	23	144	18	25	14	10	12	11	15	18	17	38
	1979	12	23	21	34	20	126	16	75	12	38	10	3	7	5	14	6
	TOTAL	60	107	76	194	77	480	75	194	53	74	39	28	48	30	58	84
	AVERAGE SPEED HOURS	15	27	19	49	19	120	19	49	13	19	10	7	12	8	15	21
JUNE	1976	9	23	12	44	16	113	17	52	10	10	8	11	9	14	13	25
	1977	12	48	15	61	17	58	13	25	11	26	10	11	9	6	11	13
	1978	14	16	13	15	12	16	12	8	9	7	12	8	12	13	12	40
	1979	13	30	17	24	17	68	15	30	11	36	10	8	10	8	19	12
	TOTAL	48	117	57	144	62	255	57	115	41	79	40	38	40	41	55	90
	AVERAGE SPEED HOURS	12	29	14	36	16	64	14	29	10	20	10	10	10	10	14	23
		NORTH		NNE		NE		ENE		EAST		ESE		SE		SSE	

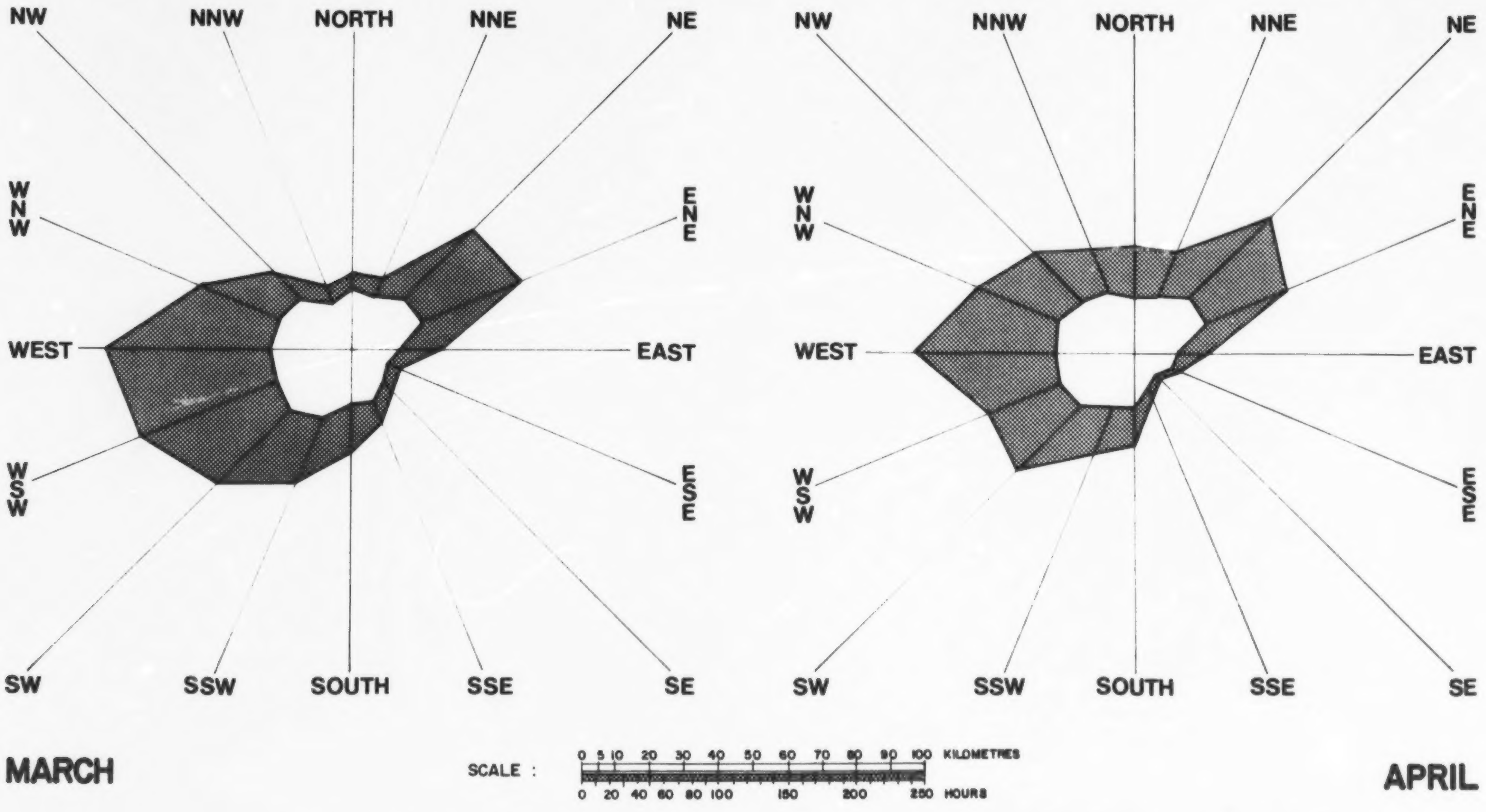
		SOUTH		SSW		SW		WSW		WEST		WNW		NW		NNW	
		SPEED	HOURS	SPEED	HOURS	SPEED	HOURS	SPEED	HOURS	SPEED	HOURS	SPEED	HOURS	SPEED	HOURS	SPEED	HOURS
JANUARY	1976	22	11	24	90	26	107	25	128	22	80	21	61	23	38	18	23
	1977	19	13	19	64	19	101	28	212	25	162	22	38	19	15	14	16
	1978	21	9	34	39	21	87	27	158	26	129	23	34	23	20	11	7
	1979	6	3	22	7	23	61	27	145	26	148	22	59	20	53	15	44
	TOTAL	68	36	99	200	89	356	107	643	99	519	88	192	85	126	58	90
	AVERAGE SPEED HOURS	17	9	25	50	22	89	27	161	25	130	22	48	21	32	15	23
FEBRUARY	1976	12	16	26	66	26	124	33	134	30	98	23	48	26	54	17	15
	1977	14	20	19	45	26	91	24	130	24	183	19	72	16	36	20	10
	1978	12	25	12	39	13	50	19	157	17	162	14	32	11	14	14	19
	1979	11	28	19	26	20	55	21	52	28	80	26	32	23	41	15	23
	TOTAL	49	89	76	176	85	320	97	473	99	523	82	184	76	145	66	67
	AVERAGE SPEED HOURS	12	22	19	44	21	80	24	118	25	131	21	46	19	36	17	17
MARCH	1976	22	41	26	98	30	92	29	60	31	103	24	81	20	15	9	5
	1977	12	26	17	31	25	91	23	129	21	89	25	68	24	54	19	19
	1978	14	13	21	25	20	58	19	132	19	164	19	54	18	28	12	16
	1979	17	56	23	45	23	53	23	104	25	123	23	44	23	16	17	6
	TOTAL	65	136	87	199	98	294	94	425	96	479	91	247	85	113	57	46
	AVERAGE SPEED HOURS	16	34	22	50	25	74	24	106	24	120	23	62	21	28	14	12
APRIL	1976	15	28	16	66	21	130	21	88	20	82	23	69	21	63	22	35
	1977	18	38	19	58	20	75	23	67	22	100	27	35	22	29	17	25
	1978	11	5	18	6	24	27	24	28	25	106	25	78	20	69	19	37
	1979	18	42	13	21	22	30	22	44	24	118	22	71	19	40	16	35
	TOTAL	62	113	66	151	87	262	90	227	91	406	97	253	82	201	74	132
	AVERAGE SPEED HOURS	16	28	17	38	22	66	23	57	23	102	24	63	21	50	19	33
MAY	1976	15	35	18	66	25	82	21	70	20	76	21	57	19	43	17	30
	1977	14	73	13	52	15	55	18	63	16	77	20	35	21	40	21	43
	1978	15	88	16	42	20	45	15	34	17	67	18	48	20	34	17	15
	1979	13	74	14	58	14	67	16	38	15	65	17	56	16	26	14	8
	TOTAL	57	270	61	218	74	249	70	205	68	285	76	196	76	143	69	96
	AVERAGE SPEED HOURS	14	68	15	55	19	62	18	51	17	71	19	49	19	36	17	24
JUNE	1976	18	35	21	61	19	79	17	49	14	66	15	39	15	34	11	13
	1977	12	42	16	49	18	74	18	61	16	106	17	52	19	38	16	26
	1978	16	96	18	82	21	55	14	48	18	133	19	110	17	44	9	8
	1979	16	59	16	118	18	96	20	51	18	50	19	59	18	36	18	17
	TOTAL	62	232	71	310	76	304	69	209	66	355	70	260	69	152	54	64
	AVERAGE SPEED HOURS	16	58	18	78	19	76	17	52	17	89	18	63	17	38	14	16
		SOUTH		SSW		SW		WSW		WEST		WNW		NW		NNW	

WIND SPEED (km/h), FREQUENCY & PREVAILING DIRECTION

Month	Year	NORTH		NNE		NE		ENE		EAST		ESE		SE		SSE		SOUTH		SSW		SW		WSW		WEST		WNW		NW		NNW	
		SPEED	HOURS	SPEED	HOURS	SPEED	HOURS	SPEED	HOURS	SPEED	HOURS	SPEED	HOURS	SPEED	HOURS	SPEED	HOURS	SPEED	HOURS	SPEED	HOURS	SPEED	HOURS	SPEED	HOURS	SPEED	HOURS	SPEED	HOURS	SPEED	HOURS	SPEED	HOURS
JULY	1976	13	34	13	38	15	49	17	50	10	8	9	3	10	6	12	13	12	39	15	62	17	107	15	103	17	92	19	40	21	50	15	27
	1977	12	20	17	31	17	50	13	23	8	6	7	6	7	2	10	7	15	50	15	74	17	105	15	107	15	102	15	57	16	42	18	28
	1978	13	44	14	28	16	78	16	37	11	11	9	6	7	1	11	5	16	86	19	107	18	97	15	75	16	61	18	36	16	26	12	29
	1979	10	24	13	23	12	37	12	14	7	14	6	3	12	4	10	17	12	71	12	132	13	93	16	37	12	90	14	73	13	56	19	20
	TOTAL	48	122	57	120	60	214	58	124	36	39	31	18	36	13	43	42	55	246	61	375	65	402	61	322	60	345	66	206	66	174	64	104
	AVERAGE SPEED HOURS	12	31	14	30	15	54	15	31	9	10	8	5	9	3	11	11	14	62	15	94	16	101	15	81	15	86	17	52	17	44	16	26
AUGUST	1976	12	52	13	41	16	49	17	58	15	32	9	10	9	3	8	3	12	9	14	49	18	108	17	79	12	82	15	45	18	76	11	34
	1977	11	15	10	26	11	41	10	43	9	14	7	6	7	2	7	4	12	38	15	87	17	130	16	98	15	121	15	71	14	52	12	27
	1978	10	26	11	37	14	84	12	32	9	20	8	7	9	2	10	12	13	60	18	80	20	90	17	88	15	75	16	27	11	23	10	18
	1979	11	15	13	28	11	86	13	88	9	22	9	3	7	5	10	8	10	41	15	64	18	81	18	57	18	88	12	57	12	45	11	27
	TOTAL	44	108	47	132	52	260	52	221	42	88	33	26	32	12	35	27	47	148	62	280	63	409	68	322	60	366	58	200	55	196	44	106
	AVERAGE SPEED HOURS	11	27	12	33	13	65	13	55	11	22	8	7	8	3	9	7	12	37	16	70	16	102	17	81	15	92	15	50	14	49	11	27
SEPTEMBER	1976	13	23	13	19	17	65	16	58	9	11	8	5	8	5	11	12	11	15	14	51	15	100	19	129	18	92	18	63	15	63	18	31
	1977	8	26	11	39	13	71	15	114	11	31	12	12	9	5	12	8	13	30	17	43	13	50	16	65	18	90	17	48	13	29	13	21
	1978	13	47	14	44	18	59	19	107	13	34	13	10	10	16	17	27	15	35	16	59	19	80	17	55	17	44	15	23	17	19	16	30
	1979	7	44	15	36	13	77	13	52	7	27	7	6	10	3	8	14	13	64	16	77	18	90	16	41	13	77	16	26	17	16	13	31
	TOTAL	41	140	53	138	61	272	63	331	40	103	40	33	37	29	48	61	42	144	63	230	65	320	68	290	66	303	66	160	62	127	60	113
	AVERAGE SPEED HOURS	10	35	13	35	15	68	16	83	10	26	10	8	9	7	12	15	11	36	16	58	16	80	17	73	17	76	17	40	16	32	15	28
OCTOBER	1976	16	67	15	81	16	105	14	38	14	18	10	6	11	7	12	20	19	33	23	36	24	55	29	98	22	66	20	43	16	40	17	26
	1977	16	35	16	33	19	63	17	62	17	22	9	14	12	11	14	21	20	44	17	39	16	67	19	74	17	71	19	57	18	44	21	40
	1978	14	29	17	35	21	20	13	12	10	20	12	11	14	6	14	13	16	68	18	104	16	130	17	80	16	90	17	49	15	31	19	28
	1979	13	8	13	21	17	91	15	59	10	21	14	4	15	6	15	13	17	56	21	59	18	96	21	92	18	104	17	52	14	26	15	17
	TOTAL	59	139	61	170	73	279	59	171	51	81	45	35	52	30	55	67	72	201	79	238	74	348	86	344	73	331	73	201	63	141	72	111
	AVERAGE SPEED HOURS	15	35	15	43	18	70	15	43	13	20	11	9	13	8	14	17	18	50	20	60	19	87	22	86	18	83	18	50	16	35	18	28
NOVEMBER	1976	10	7	6	3	7	3	9	2	9	1	9	3	11	9	12	8	20	23	24	81	20	120	24	247	21	135	18	42	17	25	10	5
	1977	17	10	20	26	24	81	23	81	14	55	14	4	10	5	12	7	17	47	19	65	18	34	24	136	22	50	21	31	21	19	16	22
	1978	10	21	18	51	19	46	15	78	16	47	12	3	25	2	20	7	17	70	19	77	18	65	26	82	22	80	18	20	17	22	10	12
	1979	14	11	12	24	16	55	17	48	11	18	12	3	8	4	10	11	15	52	18	67	20	77	15	150	21	114	17	35	14	23	15	15
	TOTAL	61	49	56	104	66	185	64	209	50	121	47	13	54	20	54	33	69	192	80	290	76	296	89	615	86	379	74	128	69	89	51	54
	AVERAGE SPEED HOURS	15	12	14	26	17	46	16	52	13	30	12	3	14	5	14	8	17	48	20	73	19	74	22	154	22	95	19	32	17	22	13	14
DECEMBER	1976	13	10	8	4	12	11	13	33	13	24	9	4	9	3	10	10	15	20	20	49	22	149	26	197	21	75	21	62	24	67	19	11
	1977	19	20	13	18	23	24	30	81	18	53	15	5	13	9	20	6	16	16	20	40	24	80	27	189	22	132	16	31	20	13	16	6
	1978	14	11	10	13	11	25	16	66	11	38	8	4	10	7	19	7	15	7	19	55	26	76	26	213	26	119	26	43	11	14	12	19
	1979	24	35	24	41	24	33	13	18	14	21	12	4	11	12	10	16	20	33	24	79	29	87	24	138	23	115	24	43	23	35	21	21
	TOTAL	70	76	55	76	70	93	72	198	56	136	44	17	43	31	59	39	66	76	83	223	101	392	103	737	92	441	87	179	78	129	68	57
	AVERAGE SPEED HOURS	18	19	14	19	18	23	18	50	14	34	11	4	11	8	15	10	17	19	21	56	25	98	26	184	23	110	22	45	20	32	17	14
YEARLY AVG. SPEED/TOTAL HRS.		14	315	16	378	18	720	18	624	13	274	12	81	11	76	13	152	15	471	19	726	20	989	21	1204	20	1185	20	602	18	434	16	262

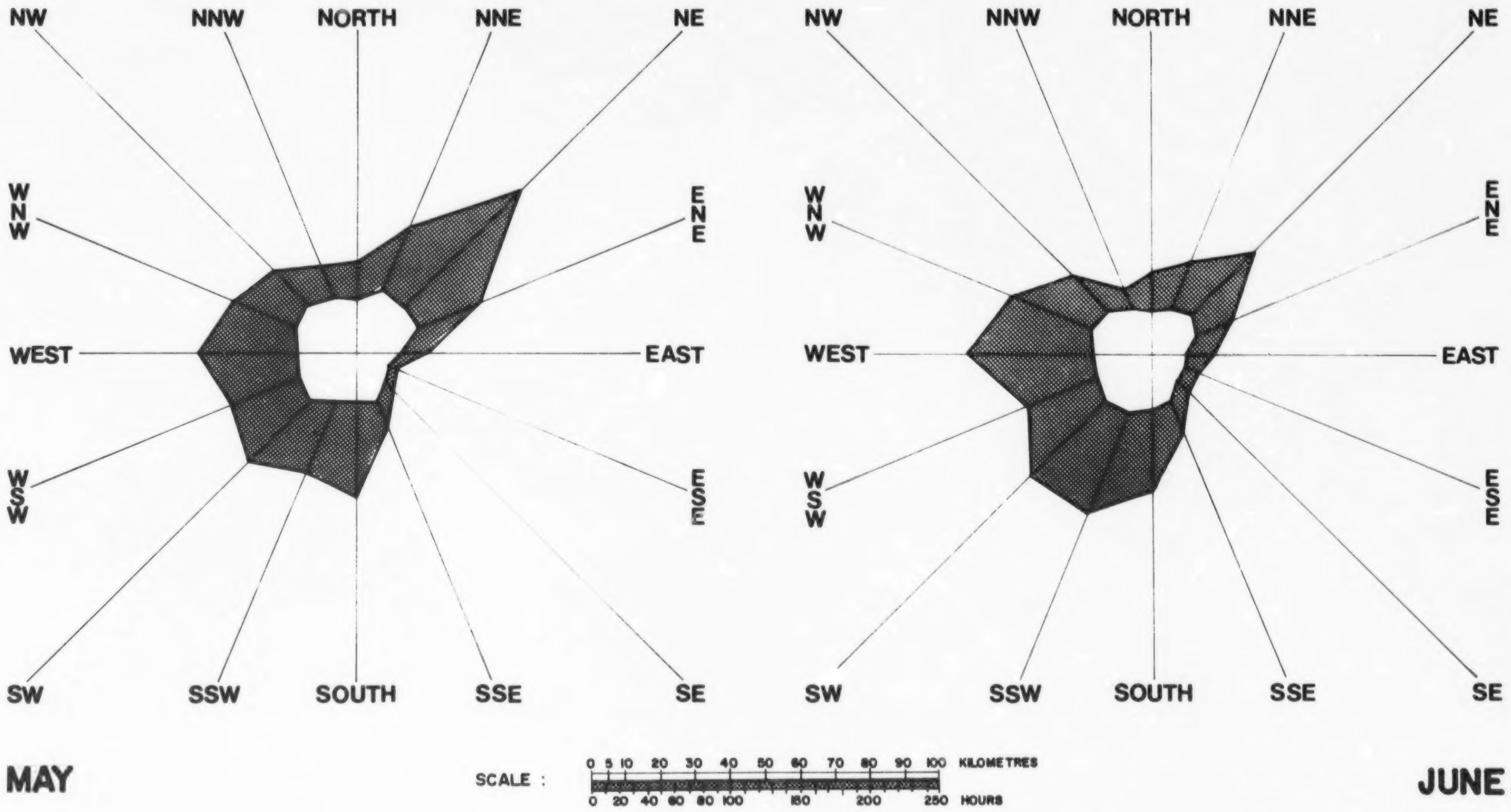


WIND SPEED(km/h), FREQUENCY & PREVAILING DIRECTION



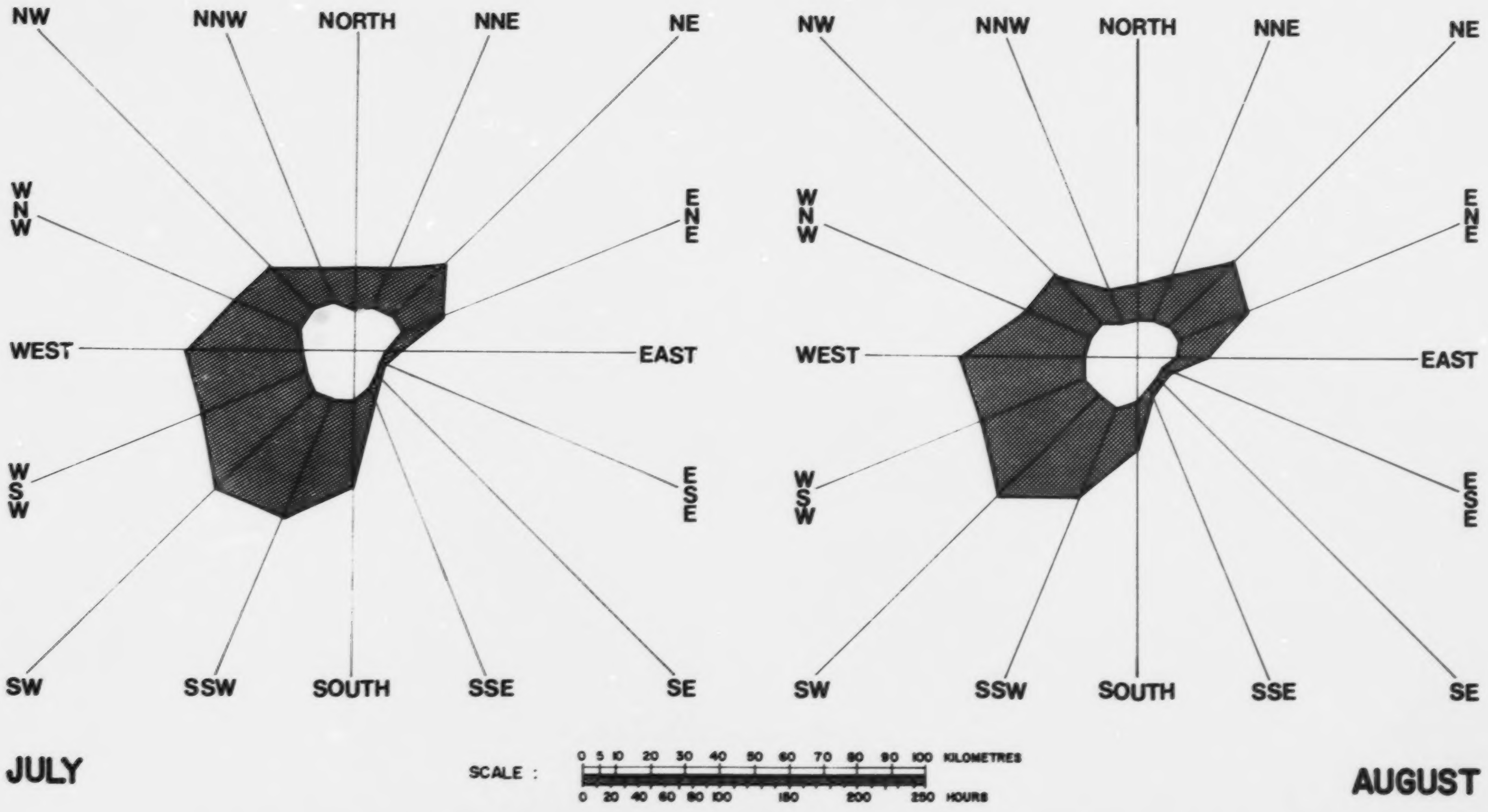
WIND SPEED (km/h), FREQUENCY & PREVAILING DIRECTION

C5



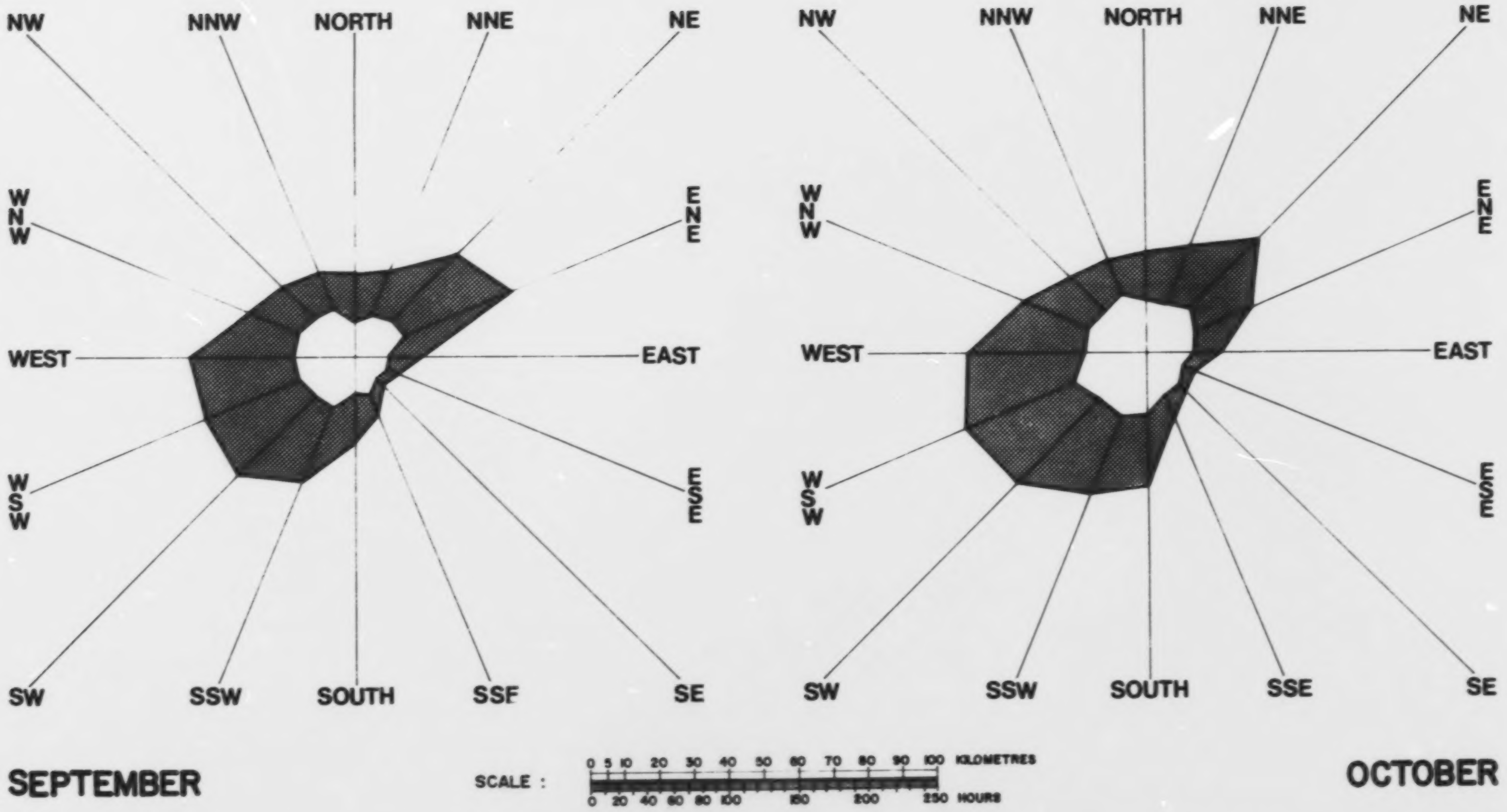
WIND SPEED(km/h), FREQUENCY & PREVAILING DIRECTION

C6



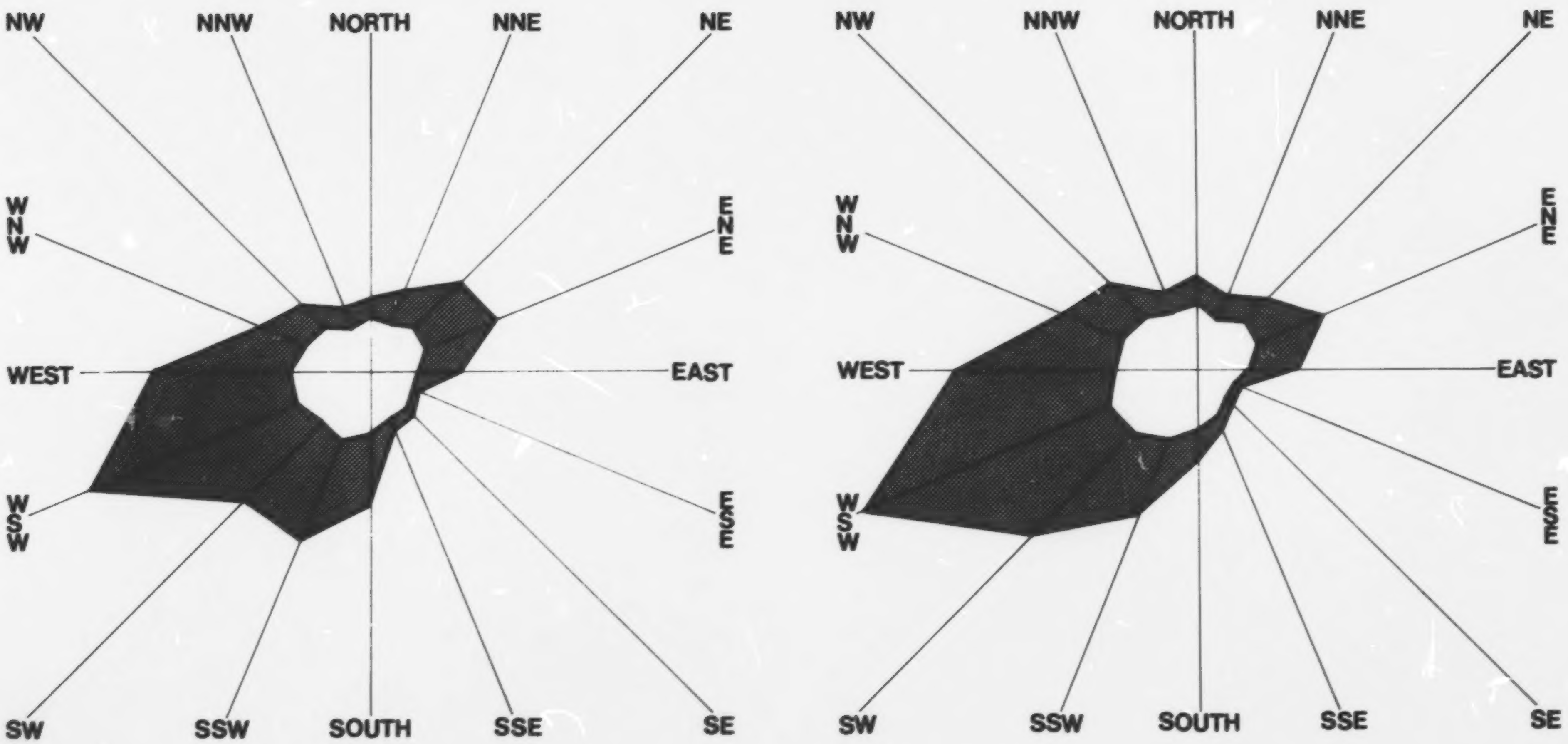
WIND SPEED(km/h), FREQUENCY & PREVAILING DIRECTION

C7



WIND SPEED(km/h), FREQUENCY & PREVAILING DIRECTION

C8



NOVEMBER

SCALE : 0 5 10 20 30 40 50 60 70 80 90 100 KILOMETRES
0 20 40 60 80 100 150 200 250 HOURS

DECEMBER

WIND SPEED(km/h), FREQUENCY & PREVAILING DIRECTION

WIND SPEED (km/h), FREQUENCY & PREVAILING DIRECTION

JANUARY 76

[illegible]

	NORTH	NNE	NE	ENE	EAST	ESE	SE	SSE	SOUTH	SSW	SW	WSW	WEST	WNW	NW	NNW
	129	411	505	411	391	94	48	68	153	1390	1716	1969	1073	780	545	281
	14.8	20.0	20.8	21.9	15.6	15.1	15.4	10.9	22.4	24.1	25.8	24.8	21.6	20.6	23.1	18.3
	14	49	39	33	31	10	5	10	11	93	107	128	80	61	38	23

HOURLY SPEED IS IN MILES. THE TOTAL AVERAGE SPEED IS CONVERTED TO KILOMETRES.

CIO

WIND SPEED (km/h), FREQUENCY & PREVAILING DIRECTION

FEBRUARY 76

[illegible]

	NORTH	NNE	NE	ENE	EAST	ESE	SE	SSE	SOUTH	SSW	SW	WSW	WEST	WNW	NW	NNW
	129	207	223	391	114	45	32	44	123	1045	2021	2735	1522	680	858	161
	13.0	16.7	17.1	17.5	13.1	12.1	10.3	11.8	12.4	25.5	26.2	32.9	30.0	23.1	25.6	17.3
	16	20	21	36	14	6	5	6	16	66	124	134	98	48	54	15

HOURLY SPEED IS IN MILES. THE TOTAL AVERAGE SPEED IS CONVERTED TO KILOMETRES.

WIND SPEED (km/h), FREQUENCY & PREVAILING DIRECTION

MARCH 76

	NORTH	NNE	NE	ENE	EAST	ESE	SE	SSE	SOUTH	SSW	SW	WSW	WEST	WNW	NW	NNW
TOTAL	75	129	1242	1653	175	107	58	125	550	1574	1727	1082	1976	1225	185	28
AVERAGE SPEED	24.1	17.3	25.3	29.2	18.8	13.3	11.7	16.8	21.6	25.9	30.2	29.0	30.9	24.3	19.9	9.0
[illegible]	5	12	79	93	15	13	8	12	41	98	92	60	103	81	15	5
	NORTH	NNE	NE	ENE	EAST	ESE	SE	SSE	SOUTH	SSW	SW	WSW	WEST	WNW	NW	NNW

HOURLY SPEED IS IN MILES. THE TOTAL AVERAGE SPEED IS CONVERTED TO KILOMETRES.

WIND SPEED (km/h), FREQUENCY & PREVAILING DIRECTION

APRIL 76

	NORTH	NNE	NE	ENE	EAST	ESE	SE	SSE	SOUTH	SSW	SW	WSW	WEST	WNW	NW	NNW
TOTAL	500	905	1726	311	20	57	6	122	406	1048	2686	1832	1657	1586	1293	778
AVERAGE SPEED	20.0	[illegible]	20.8	25.9	10.0	11.4	6.0	12.2	14.5	15.9	20.7	20.8	20.2	23.0	20.5	22.2
[illegible]	25	34	60	12	2	5	1	10	28	66	130	88	82	69	63	35
	NORTH	NNE	NE	ENE	EAST	ESE	SE	SSE	SOUTH	SSW	SW	WSW	WEST	WNW	NW	NNW

WIND SPEED (km/h), FREQUENCY & PREVAILING DIRECTION — MAY 76

	NORTH	NNE	NE	ENE	EAST	ESE	SE	SSE	SOUTH	SSW	SW	WSW	WEST	WNW	NW	NNW
TOTAL	288	555	2107	802	105	80	47	261	540	1208	2077	1497	1082	1213	813	504
AVERAGE SPEED	15.2	18.5	17.4	16.7	10.5	8.0	9.4	14.5	15.4	18.3	25.3	21.4	19.5	21.3	18.9	16.8
[illegible]	19	30	121	48	10	10	5	18	35	66	82	70	76	57	43	30

WIND SPEED (km/h), FREQUENCY & PREVAILING DIRECTION — JUNE 76

	NORTH	NNE	NE	ENE	EAST	ESE	SE	SSE	SOUTH	SSW	SW	WSW	WEST	WNW	NW	NNW
TOTAL	212	522	1829	907	100	87	132	315	611	1259	1486	822	912	582	505	140
AVERAGE SPEED	9.2	11.9	16.2	17.4	10	7.9	9.4	12.6	17.5	20.6	18.8	16.8	13.8	14.9	14.9	10.8
[illegible]	23	44	113	52	10	11	14	25	35	61	79	49	66	39	34	13

WIND SPEED (km/h), FREQUENCY & PREVAILING DIRECTION — JULY 76

Hour-by-hour wind speed entries (hours 1,2,3 through 255): [illegible]

	NORTH	NNE	NE	ENE	EAST	ESE	SE	SSE	SOUTH	SSW	SW	WSW	WEST	WNW	NW	NNW
TOTAL	452	474	730	826	79	27	60	152	480	952	1767	1539	1563	746	1027	404
AVERAGE SPEED	13.3	12.5	14.9	16.5	9.9	9.0	10.7	11.7	12.3	15.4	16.5	14.9	17.0	18.7	20.5	15.0
[illegible]	34	38	49	50	8	3	6	13	39	62	107	103	92	40	50	27

WIND SPEED (km/h), FREQUENCY & PREVAILING DIRECTION — AUGUST 76

Hour-by-hour wind speed entries (hours 1,2,3 through 255): [illegible]

	NORTH	NNE	NE	ENE	EAST	ESE	SE	SSE	SOUTH	SSW	SW	WSW	WEST	WNW	NW	NNW
TOTAL	626	514	793	1004	479	89	26	24	111	689	1906	1358	940	668	1374	371
AVERAGE SPEED	12.0	12.5	16.2	17.3	15.0	8.9	8.7	8.2	12.3	14.1	17.6	17.2	11.5	14.8	18.1	10.9
[illegible]	52	41	49	58	32	10	3	3	9	49	108	79	82	45	76	34

WIND SPEED (km/h), FREQUENCY & PREVAILING DIRECTION

SEPTEMBER 76

	NORTH	NNE	NE	ENE	EAST	ESE	SE	SSE	SOUTH	SSW	SW	WSW	WEST	WNW	NW	NNW
TOTAL	288	242	1071	926	103	39	42	134	170	726	1531	2414	1685	1311	929	558
AVERAGE SPEED	12.5	12.7	16.5	16.0	9.4	7.8	8.4	11.2	11.3	14.2	15.3	18.7	18.3	17.6	14.7	18.0
TOTAL HRS.	23	19	65	58	11	5	5	12	15	51	100	129	92	63	63	31

WIND SPEED (km/h), FREQUENCY & PREVAILING DIRECTION

OCTOBER 76

	NORTH	NNE	NE	ENE	EAST	ESE	SE	SSE	SOUTH	SSW	SW	WSW	WEST	WNW	NW	NNW
TOTAL	1048	1229	1683	529	250	59	75	230	620	811	1295	2820	1448	871	644	447
AVERAGE SPEED	15.6	15.2	16.0	13.9	13.9	9.8	10.7	11.5	18.8	22.5	23.5	28.8	21.9	20.3	16.1	17.2
TOTAL HRS.	67	81	105	38	18	6	7	20	33	36	55	98	66	43	40	26

WIND SPEED (km/h), FREQUENCY & PREVAILING DIRECTION — NOVEMBER 76

HOURS	NORTH	NNE	NE	ENE	EAST	ESE	SE	SSE	SOUTH	SSW	SW	WSW	WEST	WNW	NW	NNW
1,2,3	15 15 7	6 7 6	11 7 4	9 9	9	7 9 11	11 15 15	11 19 11	6 17 24	9 9 11	13 9 9	17 7 9	7 6 7	9 7 22	9 7 22	9 4 11
4,5,6	11 6 7						7 7 7	13 9 7	19 19 11	24 28 26	7 9 28	9 9 6	11 11 13	17 24 20	19 26 15	19 11
9	6						9 13 13	11 13	11 20 17	28 33 37	26 24 13	35 19 15	9 6 15	26 24 17	13 11 19	
12									11 13 26	33 28 13	11 19 28	7 24 30	17 6 6	22 19 19	20 22 20	
15									24 26 24	15 15 17	30 28 6	28 20 9	9 20 20	22 13 30	24 20 24	
18									26 20 22	26 32 22	26 26 15	24 6 15	19 26 15	19 20 22	41 22 7	
21									19 28 26	20 22 17	15 13 15	17 20 22	17 13 11	15 15 17	7 6 9	
24									26 30	17 13 17	13 11 22	28 11 13	11 15 19	13 11 26	13 13 15	
27										11 9 11	19 26 28	11 22 26	19 20 13	20 11 17	11	
30										32 30 24	28 32 28	37 37 37	19 13 9	9 7 11		
33										26 22 20	30 28 37	37 37 33	13 9 13	11 9 7		
36										11 9 11	33 24 17	32 11 15	9 11 11	22 22 19		
39										13 13 20	20 22 22	20 19 17	11 26 20	19 26 19		
42										22 26 28	13 13 13	17 11 11	26 15 11	20 28 17		
45										33 33 35	19 11 9	13 17 22	9 13 11			
48										35 37 30	19 13 9	24 11 15	9 9 17			
51										28 37 15	13 11 28	13 17 24	22 20 26			
54										19 11 19	22 26 17	13 13 13	19 15 13			
57										20 17 17	13 11 11	15 11 13	15 17 22			
60										20 32 30	13 11 15	13 13 9	26 32 24			
63										30 32 35	17 17 13	15 17 17	24 20 20			
66										26 30 30	7 9 9	17 17 19	19 17 37			
69										33 33 32	11 15 15	19 22 26	35 35 28			
72										35 35 28	13 11 37	28 26 24	28 28 13			
75										22 22 20	17 15 17	26 28 30	26 28 30			
78										24 22 37	17 20 28	41 35 37	26 28 33			
81										40 41 11	26 28 20	35 32 24	35 39 32			
84											24 24 32	32 37 43	33 37 41			
87											20 19 17	43 43 44	37 33 26			
90											28 28 28	37 33 32	30 26 20			
93											24 24 24	22 26 28	20 11 13			
96											22 26 24	30 32 35	15 13 9			
99											20 15 13	32 28 24	9 7 11			
102											11 15 19	20 11 15	11 11 9			
105											20 24 24	15 15 15	7 6 6			
108											24 20 17	19 22 26	44 46 43			
111											20 17 15	24 17 7	22 56 52			
114											13 15 28	7 7 11	54 15 19			
117											32 35 26	13 13 13	22 26 26			
120											39 33 26	13 13 13	26 28 17			
123												15 17 20	24 22 19			
126												28 24 22	24 24 28			
129												22 20 24	26 24 28			
132												26 22 20	28 30 28			
135												19 17 17	35 32 39			
138												15 11 17				
141												20 32 28				
144												32 28 19				
147												22 19 22				
150												32 9 7				
153												9 6 9				
156												22 28 26				
159												28 28 28				
162												26 30 30				
165												30 35 32				
168												37 35 37				
171												41 41 46				
174												37 44 33				
177												32 35 35				
180												33 35 30				
183												28 30 32				
186												32 33 35				
189												41 37 39				
192												35 41 35				
195												35 32 32				
198												30 30 33				
201												22 22 22				
204												24 19 19				
207												15 17 17				
210												56 37 33				
213												24 30 22				
216												20 13 13				
219												20 19 20				
222												22 26 33				
225												32 41 33				
228												33 33 33				
231												35 32 33				
234												30 24 22				
237												28 35 37				
240												43 30 41				
243												41 22 19				
246												20 24 28				
249												32				
252																
255																
Total	67	19	22	18	9	27	97	94	465	1942	2347	6022	2835	735	415	50
Average speed	9.6	6.3	7.3	9.0	9.0	9.0	10.8	11.8	20.2	24.0	19.6	24.4	21.0	17.5	16.6	10.0
Total hrs.	7	3	3	2	1	3	9	8	23	81	120	247	135	42	25	5
	NORTH	NNE	NE	ENE	EAST	ESE	SE	SSE	SOUTH	SSW	SW	WSW	WEST	WNW	NW	NNW

WIND SPEED (km/h), FREQUENCY & PREVAILING DIRECTION — DECEMBER 76

HOURS	NORTH	NNE	NE	ENE	EAST	ESE	SE	SSE	SOUTH	SSW	SW	WSW	WEST	WNW	NW	NNW
1,2,3	19 19 9	7 4 4	15 15 15	13 13 11	11 11 11	13 7 6	6 9 13	11 7 19	7 28 22	28 24 32	24 22 26	28 11 20	24 22 13	32 26 33	28 37 22	13 13 11
4,5,6	11 7 11	15	13 13 15	15 15 15	15 11 7	9		9 9 6	7 11 15	13 15 11	19 15 15	28 22 30	19 13 7	22 20 46	28 26 24	4 37 6
9	22 13 13		13 13 7	17 17 19	11 15 15			7 9 11	15 20 33	11 26 19	20 26 28	20 22 28	11 19 22	37 35 26	28 30 26	22 30 28
12	4		4 7	13 19 11	13 11 7			11	30 20 11	30 19 19	19 20 24	24 24 24	22 28 24	15 41 44	30 24 28	26 22
15				17 15 17	6 7 7				17 9 6	17 26 22	20 13 7	24 33 15	28 24 26	19 13 15	20 19 17	
18				15 13 7	11 15 13				6 11 9	19 22 19	7 19 17	11 26 17	17 52 54	19 22 20	17 15 15	
21				15 7 6	15 13 20				11 11	15 7 7	15 24 24	9 7 13	44 17 15	13 11 24	13 15 17	
24				9 7 6	20 20 17					7 15 20	19 22 20	22 19 24	28 30 28	32 30 26	17 37 35	
27				4 11 13						13 17 20	24 13 11	24 22 20	30 20 15	19 13 15	30 28 28	
30				13 15 11						15 17 15	11 7 22	15 17 26	17 20 20	13 9 7	24 22 26	
33				13 13 13						26 24 24	13 17 20	22 22 17	2 11 19	13 9 7	22 26 15	
36										32 30 28	17 2 9	19 26 26	17 22 7	30 37 30	28 17 17	
39										32 26 28	13 15 15	22 20 19	32 26 19	28 26 33	22 15 13	
42										30 32 30	24 26 28	15 17 17	22 19 19	35 19 17	19 20 37	
45										19 20 6	24 13 17	28 28 30	19 24 13	24 19 9	35 28 24	
48										11 7 11	20 22 20	33 24 28	15 15 15	22 17 13	24 26 32	
51										7	24 26 19	28 24 26	28 30 24	13 17 19	28 28 28	
54											15 13 13	20 19 15	24 24 15	15 13 17	30 30 32	
57											13 20 20	9 30 42	13 15 22	11 13 17	35 41 37	
60											11 13 9	46 46 50	26 30 28	24 13 11	35 28 11	
63											15 19 28	46 50 56	30 17 13	9 6	19 22 13	
66											26 30 26	57 61 50	11 13 13		9 20 11	
69											35 37 41	52 50 43	11 13 13		9	
72											46 44 48	15 13 15	17 17 37			
75											52 54 52	20 32 26	39 33 24			
78											48 48 48	26 30 30				
81											13 15 7	26 26 30				
84											13 20 19	28 37 15				
87											22 19 17	11 11 15				
90											15 13 20	50 48 41				
93											26 24 24	44 43 41				
96											15 15 13	30 24 20				
99											13 13 17	19 19 11				
102											11 19 24	15 24 28				
105											30 39 33	20 22 20				
108											35 37 28	19 26 22				
111											28 28 30	20 17 26				
114											32 28 30	28 17 26				
117											24 20 22	28 26 26				
120											17 28 30	30 32 30				
123											22 26 26	28 26 26				
126											30 26 24	30 28 20				
129											17 24 22	24 22 20				
132											19 15 15	22 24 28				
135											17 20 22	22 20 22				
138											13 15 13	19 26 28				
141											13 13 24	28 22 22				
144											7 7 9	22 15 15				
147											11 15 15	9 15 22				
150											7 24	24 26 24				
153												15 15 26				
156												22 19 19				
159												19 20 28				
162												32 28 28				
165												24 28 30				
168												32 28 28				
171												24 22 22				
174												22 19 19				
177												11 7 9				
180												9 15 19				
183												19 19 19				
186												24 26 30				
189												33 33 39				
192												41 41 43				
195												43 41 37				
198												30 32				
201																
204																
207																
210																
213																
216																
219																
222																
225																
228																
231																
234																
237																
240																
243																
246																
249																
252																
255																
Total	128	30	130	418	302	35	28	99	299	963	3198	5017	1605	1283	1612	212
Average speed	12.8	7.5	11.8	12.7	12.6	8.8	9.3	9.9	15.0	19.7	21.5	25.5	21.4	20.7	24.1	19.3
Total hrs.	10	4	11	33	24	4	3	10	20	49	149	197	75	62	67	11
	NORTH	NNE	NE	ENE	EAST	ESE	SE	SSE	SOUTH	SSW	SW	WSW	WEST	WNW	NW	NNW

WIND SPEED (km/h), FREQUENCY & PREVAILING DIRECTION

JANUARY 77

	NORTH	NNE	NE	ENE	EAST	ESE	SE	SSE	SOUTH	SSW	SW	WSW	WEST	WNW	NW	NNW
Total	99	193	196	321	310	72	24	105	249	1190	1872	5863	4053	849	282	218
Average speed	14.1	19.3	15.1	29.2	31.0	18.0	12.0	15.0	19.2	18.6	18.5	27.7	25.0	22.3	18.8	13.6
[illegible]	7	10	13	11	10	4	2	7	13	64	101	212	162	38	15	16

WIND SPEED (km/h), FREQUENCY & PREVAILING DIRECTION

FEBRUARY 77

	NORTH	NNE	NE	ENE	EAST	ESE	SE	SSE	SOUTH	SSW	SW	WSW	WEST	WNW	NW	NNW
Total	30	6	623	946	72	43	116	71	281	836	2341	3092	4472	1399	583	195
Average speed	10.0	6.0	31.2	27.0	18.0	14.3	14.5	11.8	14.1	18.6	25.7	23.8	24.4	19.4	16.2	19.5
[illegible]	3	1	20	35	4	3	8	6	20	45	91	130	183	72	36	10

WIND SPEED (km/h), FREQUENCY & PREVAILING DIRECTION

MARCH 77

HOURS	NORTH	NNE	NE	ENE	EAST	ESE	SE	SSE	SOUTH	SSW	SW	WSW	WEST	WNW	NW	NNW
1,2,3	17 30 28	26 39 39	15 28 24	24 30 30	7 13 22	13 13 13	15 20 17	13 6 15	9 13 6	9 13 35	11 17 20	15 15 26	32 28 26	28 37 30	20 24 15	13 35 37
4,5,6	17 17 15	9 9	28 28 28	28 26 19	15 13 15	15 11 11	17 11 11	11 13 11	11 11 15	28 24 24	20 33 20	22 24 22	22 35 35	33 19 24	20 11 37	37 37 32
9	48 44 19		32 32 17	22 24 28	15 7 30	9 11 15	9 11 13	7 17 19	13 15 13	20 22 17	20 20 19	19 26 26	33 33 32	24 24 32	28 20 20	26 26 19
12	11 9 9		19 20 24	13 15 15	9 19 7		9 9 13	17 15 13	17 15 13	19 22 11	9 13 9	28 28 37	26 24 26	20 28 20	22 28 26	15 17 13
15	11		24 24 22	17 20 22	9 6 9		15	13 15 9	13 11 11	7 7 11	52 41 35	35 30 32	28 24 24	13 44 30	22 22 24	13 11 7
18			24 22 22	22 13 15	6 9 9				7 15 15	11 7 13	39 39 43	26 19 17	22 19 26	37 30 26	9 9 26	7 7 6
21			13 9 13	17 17 9	11 15 17				13 13 20	22 7 17	46 37 44	13 13 13	26 30 22	28 28 41	26 24 20	6
24			24 19 20	19 17 7	11 11 9				7 9 11	15 13 11	44 48 41	15 37 48	24 22 19	33 28 35	20 37 39	
27			19 22 22	11 28 30	9 6 9				4 13	11 13 17	41 32 15	48 44 46	17 19 17	28 26 32	41 37 37	
30			19 19 17	30 37 26	15 11					22 24 32	11 9 11	43 50 46	22 15 13	20 32 24	37 26 32	
33			17 17 17	28 37 41						20	15 13 13	46 50 52	19 13 11	28 22 13	28 28 35	
36			11 17 13	11 17 20							13 11 15	48 37 39	6 28 20	13 7 11	22 28 22	
39			17 13 13	32 26 19							15 20 24	39 28 30	19 11 11	37 37 37	30 30 22	
42			15 11 11	17 15 24							17 15 17	32 20 19	13 15 15	26 11 20	22 17 17	
45			15 19 17	33 37							24 22 24	20 26 24	17 13 19	32 37 22	6 17 15	
48			15 19 51	37 41 44							26 35 37	26 26 20	28 26 22	35 37 37	20 15 19	
51			56 54 56	46 50 50							41 44 33	13 17 13	11 9 11	30 35 11	9 19 6	
54			48 41 4	44 9 13							32 30 33	11 9 13	6 33 41	13 11 19	33 32 13	
57			24 24 50	20 22 24							35 30 32	13 13 13	39 43 48	9 7 20		
60			63 54 7	24 9 13							15 17 20	15 15 19	39 19 11	11 11 30		
63			24 20 19	13 13 15							6 24 11	17 15 24	11 15 15	33 33 28		
66			15 15	11 11 11							13 7 13	37 33 33	15 9 13	26 22 11		
69											9 15 20	24 17 17	13 30 30	17 13		
72											20 13 7	15 30 35	22 20 17			
75											6 9 6	32 19 22	20 11 11			
78											11 9 28	13 13 15	17 19 15			
81											32 46 46	19 26 28	26 13 11			
84											41 41 33	24 24 26	11 7 6			
87											30 26 24	22 6 30	22 37 26			
90											33 41 41	24 26 26	30 41			
93											26	24 30 11				
96												15 6 13				
99												9 7 11				
102												13 13 17				
105												13 17 17				
108												13 15 13				
111												17 17 17				
114												19 24 28				
117												15 13 41				
120												20 15 11				
123												39 33 28				
126												11 20 20				
129												22 26 24				
TOTAL	275	122	1541	1545	344	111	159	194	321	534	2244	3014	1860	1706	1274	364
AVERAGE SPEED	21.2	24.4	23.7	23.4	11.9	12.3	12.2	12.9	12.3	17.2	24.7	23.4	20.9	25.1	23.6	19.2
TOTAL HRS.	13	5	65	66	29	9	13	15	26	31	91	129	89	68	54	19
	NORTH	NNE	NE	ENE	EAST	ESE	SE	SSE	SOUTH	SSW	SW	WSW	WEST	WNW	NW	NNW

WIND SPEED (km/h), FREQUENCY & PREVAILING DIRECTION

APRIL 77

HOURS	NORTH	NNE	NE	ENE	EAST	ESE	SE	SSE	SOUTH	SSW	SW	WSW	WEST	WNW	NW	NNW
1,2,3	28 19 19	9 6 11	11 26 15	15 11 24	9 19 9	11 9 11	6 9 2	11 22 22	13 13 7	22 24 30	28 28 26	37 30 19	11 44 46	13 13 41	13 11 30	9 11 20
4,5,6	13 9 7	9 9 7	20 24 24	19 19 13	9 9 13	13 6 6	13 7	11 11 3	26 30 37	30 26 13	28 33 37	46 56 41	7 11 46	44 37 33	19 7 22	17 11 6
9	11 13 6	9 9 7	24 26 28	7 22 15	9 9			17 7 11	30 11 15	19 28 20	41 33 35	19 13 13	30 44 41	37 30 22	24 30 32	22 19 13
12	7 9 11	13 11 13	28 26 26	17 17 17	7 6 7				22 22 26	11 11 11	46 61 46	11 7 17	30 41 35	24 22 22	30 30 26	4 7 6
15	9 24 20	7 20 26	28 24 7	19 22 26	11 15 7				24 26 13	19 19 22	43 11 11	19 24 26	37 37 30	28 37 37	26 22 20	22 26 28
18	15 9 15	24 26 19	33 37 22	30 32 28	7 9 17				15 26 26	28 22 26	28 26 22	30 39 30	28 33 24	35 33 28	26 26 11	24 24 24
21	6 6 13	22 22 26	24 19 7	37 33 33	9 11 9				15 7 9	24 9 11	13 13 13	33 33 32	26 30 30	37 28 24	30 15 13	19 26 22
24	7 26 19	22 13 6	13 13 15	33 28 30	6 6 7				13 7 7	9 11 22	7 9 7	32 28 24	30 30 24	26 26 26	22 28 13	19 17 19
27	22	6 6 11	13 11 13	24 28 28	11				15 11 17	17 15 13	11 11 11	24 26 26	24 22 19	24 26 28	24 24 24	20
30			13 13 7	15 19 11					17 19 13	4 19 17	11 30 35	26 26 26	15 17 30	26 22 28	22 19	
33			11 13 11	9 11 13					17 22 19	17 13 13	37 19 11	28 24 17	22 24 19	19 6 9		
36			15 13 9	11 15 13					19 28 11	11 17 19	13 13 11	13 13 11	11 9 9	13 24		
39			11 13 13	9 4 11					13 9	22 26 9	17 9 9	17 17 17	11 15 11			
42			15 11 13	9 13 17						13 13 9	11 13 13	19 20 20	9 11 9			
45			13 17 20	17 22 20						13 4 17	22 20 28	22 22 24	20 24 28			
48			17 22 19	19 22 15						17 22 30	30 22 15	33 28 38	24 6 17			
51			20 19 15	7 7 30						24 30 28	13 9 20	7 11 11	26 28 20			
54			13 11 13	39 30 30						24 24 13	17 20 13	15 13 20	26 28 28			
57			9 28 39	33 33 30						13 19 20	9 11 11	17 11 15	30 28 32			
60			33 35 37	43 13 15						9	13 17 32	15 13 35	28 22 35			
63			30 41 37	9 11 7							37 43 28	37 22 19	37 28 13			
66			35 37 37	19 13 6							13 11 9	13 13 24	15 11 9			
69			37 41 37	6 11							11 17 11	24	17 19 6			
72			41 37 33								11 13 26		13 15 13			
75			33 37 33								19 15 11		13 9 15			
78			32 28 24										6 15 15			
81			24 22 22										15 15 13			
84			15 13 17										13 13 13			
87			15 15 9										15 20 20			
90			15 17 17										28 26 37			
93			15 17 13										33 33 30			
96			11										26 30 22			
99													15 13 11			
102													15			
TOTAL	343	349	1985	1314	240	56	37	115	670	1076	1498	1548	2207	928	639	435
AVERAGE SPEED	13.7	12.9	21.1	19.3	9.6	9.3	7.4	12.8	17.6	18.6	20.0	23.1	22.1	26.5	22.0	17.4
TOTAL HRS.	25	27	94	68	25	6	5	9	38	58	75	67	100	35	29	25
	NORTH	NNE	NE	ENE	EAST	ESE	SE	SSE	SOUTH	SSW	SW	WSW	WEST	WNW	NW	NNW

WIND SPEED (km/h), FREQUENCY & PREVAILING DIRECTION

MAY 77

HOURS	NORTH	NNE	NE	ENE	EAST	ESE	SE	SSE	SOUTH	SSW	SW	WSW	WEST	WNW	NW	NNW
1,2,3 – 255	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TOTAL	844	961	1528	1113	254	36	33	259	998	699	816	1105	1241	701	822	895
AVERAGE SPEED	20.1	16.9	17.2	24.2	15.9	9.0	16.5	11.8	13.7	13.4	14.8	17.5	16.1	20.0	20.6	20.8
TOTAL HRS.	42	57	89	46	16	4	2	22	73	52	55	63	77	35	40	43
	NORTH	NNE	NE	ENE	EAST	ESE	SE	SSE	SOUTH	SSW	SW	WSW	WEST	WNW	NW	NNW

WIND SPEED (km/h), FREQUENCY & PREVAILING DIRECTION

JUNE 77

HOURS	NORTH	NNE	NE	ENE	EAST	ESE	SE	SSE	SOUTH	SSW	SW	WSW	WEST	WNW	NW	NNW
1,2,3 – 255	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TOTAL	569	908	966	324	277	110	53	145	504	779	1346	1096	1647	905	703	423
AVERAGE SPEED	11.9	14.9	16.7	13.0	10.7	10.0	8.8	11.2	12.0	15.9	18.2	18.0	15.5	17.4	18.5	16.3
TOTAL HRS.	48	61	58	25	26	11	6	13	42	49	74	61	106	52	38	26
	NORTH	NNE	NE	ENE	EAST	ESE	SE	SSE	SOUTH	SSW	SW	WSW	WEST	WNW	NW	NNW

WIND SPEED (km/h), FREQUENCY & PREVAILING DIRECTION

JULY

HOURS	NORTH	NNE	NE	ENE	EAST	ESE	SE	SSE	SOUTH	SSW	SW	WSW	WEST	WNW	NW	NNW
TOTAL	244	522	845	294	48	42	13	73	733	1109	1729	1639	1546	847	658	502
AVERAGE SPEED	12.2	16.8	16.9	12.8	8.0	7.0	6.5	10.4	14.7	15.0	16.5	15.3	15.2	14.9	15.7	17.9
[illegible]	20	31	50	23	6	6	2	7	50	74	105	107	102	57	42	28
	NORTH	NNE	NE	ENE	EAST	ESE	SE	SSE	SOUTH	SSW	SW	WSW	WEST	WNW	NW	NNW

WIND SPEED (km/h), FREQUENCY & PREVAILING DIRECTION

AUGUST

HOURS	NORTH	NNE	NE	ENE	EAST	ESE	SE	SSE	SOUTH	SSW	SW	WSW	WEST	WNW	NW	NNW
TOTAL	170	271	453	411	132	42	13	28	450	1329	2250	1591	1758	1088	718	335
AVERAGE SPEED	11.3	10.4	11.0	9.6	9.4	7.0	6.5	7.0	11.8	15.3	17.3	16.2	14.5	15.3	13.8	12.4
[illegible]	15	26	41	43	14	6	2	4	38	87	130	98	121	71	52	27
	NORTH	NNE	NE	ENE	EAST	ESE	SE	SSE	SOUTH	SSW	SW	WSW	WEST	WNW	NW	NNW

WIND SPEED (km/h), FREQUENCY & PREVAILING DIRECTION — SEPTEMBER

HOURS	NORTH	NNE	NE	ENE	EAST	ESE	SE	SSE	SOUTH	SSW	SW	WSW	WEST	WNW	NW	NNW
1,2,3 … 255	[illegible]															
TOTAL	217	423	920	1734	324	147	46	92	390	745	650	1067	1599	823	377	274
AVERAGE SPEED	8.3	10.8	13.0	15.2	10.5	12.3	9.2	11.5	13.0	17.3	13.0	16.4	17.8	17.1	13.0	13.0
[illegible]	26	39	71	114	31	12	5	8	30	43	50	65	90	48	29	21
	NORTH	NNE	NE	ENE	EAST	ESE	SE	SSE	SOUTH	SSW	SW	WSW	WEST	WNW	NW	NNW

WIND SPEED (km/h), FREQUENCY & PREVAILING DIRECTION — OCTOBER 77

HOURS	NORTH	NNE	NE	ENE	EAST	ESE	SE	SSE	SOUTH	SSW	SW	WSW	WEST	WNW	NW	NNW
1,2,3 … 255	[illegible]															
TOTAL	548	538	1223	1051	367	127	129	299	876	666	1097	1439	1194	1082	774	854
AVERAGE SPEED	15.7	16.3	19.4	17.0	16.7	9.1	11.7	14.2	19.9	17.1	16.4	19.4	16.8	19.0	17.6	21.0
[illegible]	35	33	63	62	22	14	11	21	44	39	67	74	71	57	44	40
	NORTH	NNE	NE	ENE	EAST	ESE	SE	SSE	SOUTH	SSW	SW	WSW	WEST	WNW	NW	NNW

WIND SPEED (km/h), FREQUENCY & PREVAILING DIRECTION

NOVEMBER 77

HOURS	NORTH	NNE	NE	ENE	EAST	ESE	SE	SSE	SOUTH	SSW	SW	WSW	WEST	WNW	NW	NNW
1,2,3	11 20 20	9 22 24	11 9 7	6 6 4	6 4 11	7 15 20	6 11 11	6 17 9	15 19 13	15 26 26	6 7 7	6 7 22	24 22 30	13 15 13	6 30 24	11 15 24
4,5,6	22 24 24	24 22 26	38 35 37	30 32 32	11 9 9	13	13 7	7 11 17	13 13 17	24 7 7	11 11 22	28 28 32	28 26 35	20 13 11	15 15 17	24 30 32
9	15 19 7	22 22 28	37 33 37	37 37 35	9 7 11			15	19 19 22	7 20 13	26 28 19	37 26 22	35 37 43	7 7 13	17 19 11	28 19 11
12	4	32 26 30	35 33 33	37 37 37	11 13 13				30 30 24	15 11 19	24 17 11	22 26 20	48 33 32	19 7 15	7 24 15	17 17 13
15		30 19 19	26 32 32	33 33 37	15 19 19				17 9 20	15 11 11	11 7 9	20 22 30	26 24 19	28 37 37	7 33 37	13 9 13
18		17 19 20	30 30 30	37 35 32	19 26 20				11 19 17	13 15 17	30 19 20	28 26 24	9 7 11	37 48 37	44 48 17	13 15 15
21		19 19 15	30 30 30	30 32 30	22 9 6				15 11 11	13 13 13	24 26 26	28 28 32	26 19 24	37 41 37	7	19 11 6
24		17 7 7	28 30 30	30 32 28	13 17 19				15 13 13	15 11 15	20 20 19	28 35 37	28 26 19	38 30 24		4
27		9 7	22 22 26	32 37 41	20 20 20				11 9 7	11 28 19	13 32 19	48 32 30	20 13 6	19 13 15		
30			28 32 32	38 28 39	22 19 19				4 7 9	28 30 28	17 11 20	28 7 6	7 32 30	9 7 13		
33			32 32 32	38 41 33	9 15 19				13 13 13	24 26 26	19 20 20	7 11 11	26 30 26	7		
36			30 30 32	33 30 24	15 19 19				18 22 22	20 13 19	7	11 22 20	11 13 22			
39			32 38 33	26 22 26	15 9 19				33 24 26	24 22 26		37 17 28	24 19 19			
42			30 33 33	22 28 15	20 20 17				11 22 22	28 28 28		32 33 30	32 19 19			
45			32 33 24	17 15 22	19 22 17				30 35 17	22 22 20		26 30 30	15 22 15			
48			26 22 20	17 11 6	6 4 6				15 7	20 17 17		33 38 41	13 11 13			
51			15 20 20	9 20 13	6 9 9					20 24 11		43 41 35	11 11			
54			24 15 15	7 22 20	9 11 11					9 7 20		33 32 30				
57			17 19 17	19 20 13	13					33 37 33		30 26 33				
60			13 13 15	15 9 19						33 33 26		35 33 24				
63			11 9 13	9 11 7						19 19 6		24 28 24				
66			17 19 19	9 9 11								24 22 24				
69			15 20 17	13 15 19								22 19 20				
72			19 13 17	17 20 22								24 11 11				
75			13 4 6	22 22 17								26 30 28				
78			11 7 9	15 11 15								19 19 24				
81			15 30 15	9 11 13								22 19 19				
84												15 13 15				
87												15 15 9				
90												33 24 39				
93												35 32 37				
96												17 20 22				
99												22 24 28				
102												26 28 28				
105												24 24 26				
108												24 22 13				
111												17 19 26				
114												20 15 26				
117												9 13 15				
120												19 13 13				
123												13 11 17				
126												22 24 24				
129												24 33 28				
132												24 26 24				
135												19 9 11				
138												7				
TOTAL	166	511	1947	1833	761	55	48	82	782	1228	598	3228	1110	662	393	359
AVERAGE SPEED	16.6	19.6	24.0	22.6	13.8	13.7	9.6	11.7	16.6	18.9	17.6	23.7	22.2	21.4	20.7	16.3
[illegible]	10	26	81	81	55	4	5	7	47	65	34	136	50	31	19	22
	NORTH	NNE	NE	ENE	EAST	ESE	SE	SSE	SOUTH	SSW	SW	WSW	WEST	WNW	NW	NNW

WIND SPEED (km/h), FREQUENCY & PREVAILING DIRECTION

DECEMBER 77

HOURS	NORTH	NNE	NE	ENE	EAST	ESE	SE	SSE	SOUTH	SSW	SW	WSW	WEST	WNW	NW	NNW
1,2,3	9 7 9	9 7 11	15 19 69	15 19 13	15 11 6	13 22 9	7 6 9	13 9 19	9 22 26	26 41 48	52 56 52	54 43 56	22 20 22	19 24 26	19 17 22	19 22 20
4,5,6	6 37 41	11 17 13	78 15 6	11 9 48	19 20 24	9 22	17 11 13	20 30 26	13 13 22	15 24 32	41 37 46	52 52 46	15 17 15	9 9 17	20 22 19	19 9 7
9	37 35 28	9 9 7	9 11 15	46 56 48	30 35 39		17 15 19		22 22 19	30 19 15	33 19 28	37 37 44	24 13 19	17 9 20	33 11 20	
12	24 24 22	11 15 13	30 37 39	56 67 46	37 35 44				7 17 9	15 15 20	20 22 28	48 50 61	15 13 20	19 22 20	24 13 15	
15	19 11 11	13 19 17	22 13 11	52 24 20	7 13 17				9 30 7	19 22 26	13 11 33	52 48 44	20 26 26	20 22 32	13	
18	13 7 11	19 20 20	11 13 11	19 13 19	15 26 28				6	26 22 13	30 11 24	37 37 41	20 17 15	22 22 13		
21	13 11		13 19 20	22 24 24	26 26 11					20 22 26	28 20 20	37 41 48	15 17 20	15 19 11		
24			19 22 24	22 24 26	11 13 15					24 22 19	20 24 19	37 33 35	17 22 22	9 11 13		
27				30 28 30	19 9 15					11 11 11	20 17 17	37 37 41	15 17 17	17 13 11		
30				33 37 41	11 11 11					15 22 9	24 24 20	32 30 33	20 24 17	15 11 9		
33				43 39 41	15 15 13					7 11 26	19 19 11	30 26 28	11 15 13	7		
36				41 44 38	11 11 7					15 9 20	9 9 9	26 11 13	9 11 7			
39				37 46 44	15 15 13					15 35 15	9 11 15	20 17 17	9 33 19			
42				37 41 41	19 20 22					11	19 22 11	17 22 20	19 17 17			
45				33 33 43	24 26 19						11 9 7	20 26 33	13 15 13			
48				39 37 37	19 19 13						11 11 9	15 15 13	17 13			
51				37 41 35	11 11 7						15 19 19	15 9 38	13 11 15			
54				37 41 37	20 22						30 41 33	43 43 46	13 11 11			
57				43 37 35							39 41 41	48 48 56	11 11 9			
60				37 37 37							39 37 30	59 63 56	11 13 15			
63				33 30 28							35 38 37	56 52 26	7 7 11			
66				22 11 7							35 35 35	30 26 20	11 11 19			
69				13 13 11							28 15 17	17 11 9	11 13 15			
72				15 11 11							13 13 30	11 9 9	17 19 17			
75				11 11 13							26 28 24	13 11 7	15 15 13			
78				15 11 13							22 19 15	7 11 11	20 30 44			
81				13 15 20							20 11	6 19 24	61 58 56			
84												20 24 24	52 50 35			
87												20 11 11	33 41 41			
90												13 13 9	41 37 35			
93												15 7 19	33 30 32			
96												11 13 15	28 33 33			
99												11 20 22	33 35 35			
102												26 39 26	35 35 33			
105												32 35 41	32 33 33			
108												39 30 46	30 30 28			
111												41 28 32	24 26 24			
114												44 41 41	30 33 30			
117												37 37 24	28 33 30			
120												22 30 22	22 20 17			
123												22 17 15	17 15 17			
126												19 15 13	17 22 19			
129												19 33 35	22 30 20			
132												32 33 37	15 15 15			
135												37 39 37				
138												41 39 33				
141												24 26 30				
144												32 26 26				
147												33 30 28				
150												26 30 17				
153												17 15 15				
156												15 13 17				
159												17 22 20				
162												24 20 26				
165												20 20 22				
168												20 26 19				
171												17 19 19				
174												19 19 17				
177												15 22 30				
180												30 28 26				
183												19 19 15				
186												11 20 20				
189												9 6 6				
TOTAL	375	240	541	2407	966	75	114	117	253	789	1905	5098	2926	493	259	96
AVERAGE SPEED	18.6	13.3	22.5	29.7	18.2	15.0	12.7	19.5	15.8	19.7	23.8	27.0	22.2	15.9	19.9	16.0
[illegible]	20	18	24	81	53	5	9	6	16	40	80	189	132	31	13	6
	NORTH	NNE	NE	ENE	EAST	ESE	SE	SSE	SOUTH	SSW	SW	WSW	WEST	WNW	NW	NNW

WIND SPEED (km/h), FREQUENCY & PREVAILING DIRECTION

JANUARY 76

Directions across the chart: NORTH, NNE, NE, ENE, EAST, ESE, SE, SSE, SOUTH, SSW, SW, WSW, WEST, WNW, NW, NNW

Hours	Readings
1,2,3	30 28 20 28 48 37 15 22 20 39 24 22 24 24 28 24 24 22 6 11 17 15 6 7 19 22 24 26 11 11 17 13 19 28 15 17 19 13 17 26 15 19 30 13 7 7
4,5,6	6 11 41 39 41 37 19 19 17 20 22 30 30 33 26 22 7 6 26 24 19 24 20 24 28 26 32 32 28 46 19 13 9 19 33 30 26 26 22 9 6 20
9	33 30 22 37 37 41 26 22 24 22 28 26 33 33 26 22 17 48 7 7 7 32 35 32 37 43 37 44 35 33 33 28 28 24 39 24 15
12	26 20 20 39 37 26 22 19 20 30 30 33 28 32 28 13 22 22 7 11 44 37 43 33 30 33 30 20 22 17 32 33 22
15	19 19 24 13 9 7 17 44 37 37 35 30 22 11 11 20 17 19 22 22 15 30 32 28 32 32 32 17 56 52 37 33 6
18	11 20 15 17 17 24 46 48 48 35 33 33 19 28 39 20 20 19 7 30 13 30 11 17 33 32 37 52 37 41 4 7 26
21	11 15 15 22 17 22 41 19 30 33 32 26 6 11 22 22 20 22 22 20 15 11 35 28 26 24 22 13 19 22
24	37 39 37 52 50 44 22 22 24 22 20 9 26 26 22 9 11 17 22 19 15 19 17 17
27	33 30 26 46 48 7 22 20 20 4 72 56 20 15 11 39 35 35 19 30 11 13 11 17
30	33 24 22 7 11 19 20 19 17 63 63 70 13 11 6 28 24 22 9 7 15 20 20 9
33	17 7 15 32 32 48 19 15 15 74 76 78 9 9 11 22 20 19 15 9 33 6 7 15
36	20 22 22 37 11 17 15 13 13 67 89 74 11 15 22 19 6 46 30 39 50 13
39	22 24 26 19 22 30 11 11 11 67 15 13 28 30 17 15 17 30 50 52 56
42	32 41 35 30 30 33 11 19 17 24 26 30 39 32 44 46 48 46
45	37 41 37 35 39 43 19 20 22 20 22 22 44 43 39 39 26 56
48	33 33 30 17 17 19 19 19 19 20 46 46 46 52 61 59
51	30 34 30 20 24 28 20 18 15 35 33 37 61 50 67
54	26 26 22 48 52 30 17 22 19 35 37 33 52 59 50
57	19 7 9 48 46 37 22 19 22 37 32 26 37 19 17
60	50 11 6 22 22 19 24 22 26 35 39 11
63	37 32 44 17 28 19 28 28 22 9 15 17
66	43 41 52 26 26 22 19 22 28 15 22 20
69	43 48 46 26 26 22 22 17 15 6 11 7
72	39 30 41 22 4 59 19 15 19 7 7 11
75	32 44 44 56 20 15 22 26 26 13 17 15
78	50 59 69 15 17 22 32 28 35 13 15 13
81	59 33 15 17 15 32 32 26 13 13 15
84	19 17 20 22 26 26 9 20 26
87	22 24 20 22 24 20 46 37 37
90	19 15 13 37 41 30
93	13 24 11 26 19 20
96	6 13 13 15 13 11
99	13 13 11 19 17 17
102	11 11 22 19 9 11
105	26 30 28 15 15 22
108	24 22 22 19 22 24
111	24 20 19 26 20 19
114	19 24 17 19 9 19
117	15 57 54 20 19 22
120	52 48 46 20 20 20
123	44 39 48 17 19 19
126	43 46 44 22 26 22
129	43 46 43 20 28 26
132	37 41 28
135	24 30 32
138	30 13 13
141	13 15 19
144	13 11 20
147	24 15 17
150	15 15 26
153	24 22 26
156	20 26 26
159	22 33

	NORTH	NNE	NE	ENE	EAST	ESE	SE	SSE	SOUTH	SSW	SW	WSW	WEST	WNW	NW	NNW
Total	436	1571	1344	2375	481	99	6	49	188	1320	1806	4205	3292	784	466	77
Average speed	20.8	27.6	29.2	30.1	25.3	19.8	6.0	12.3	20.9	33.8	20.8	26.6	25.5	23.1	23.3	11.0
[illegible]	21	57	46	79	19	5	1	4	9	39	87	158	129	34	20	7

WIND SPEED (km/h), FREQUENCY & PREVAILING DIRECTION

FEBRUARY 76

Directions across the chart: NORTH, NNE, NE, ENE, EAST, ESE, SE, SSE, SOUTH, SSW, SW, WSW, WEST, WNW, NW, NNW

Hours	Readings
1,2,3	6 7 6 11 11 9 9 11 9 7 11 11 11 11 6 7 6 11 11 11 11 11 6 19 15 6 6 6 11 9 9 28 19 19 24 17 28 13 7 11 11 13 6 17 15 15
4,5,6	7 11 9 15 11 9 9 9 9 15 15 13 9 6 7 15 19 19 11 15 19 9 6 7 22 22 26 28 11 15 13 11 7 7 19 6 7 22 22
9	15 11 9 13 20 26 19 22 30 17 17 22 17 15 13 11 9 19 9 13 11 22 22 22 13 13 15 7 7 7 6 7 11 14 15 11
12	26 28 26 28 32 26 30 38 32 19 22 26 11 11 11 13 13 11 11 22 17 24 26 28 13 17 15 15 9 17 11 15 30 11 9 9
15	26 22 26 26 24 26 32 11 7 28 28 11 11 13 15 17 19 17 20 17 24 22 19 17 17 19 11 11 13 9 9 13 7 17
18	26 24 24 26 11 15 22 30 9 11 9 17 13 15 17 20 24 17 17 13 9 11 9 9 11 11 11 11 15
21	26 28 28 22 24 26 11 11 13 15 13 17 15 13 7 11 13 6 13 7 6 11 9 7 11
24	26 30 24 26 28 24 11 13 7 15 13 7 9 7 11 6 7 7 6 11 17 11 11 13
27	20 17 17 26 24 26 6 7 7 17 13 13 9 11 11 11 13 13 17 26 32 24
30	19 30 30 22 22 22 11 7 11 13 15 30 17 19 19 11 13 15 30 35 9
33	30 30 32 20 17 15 11 7 6 19 24 22 13 17 17 17 15 15 11 11
36	30 32 33 13 13 6 7 9 7 24 19 17 17 20 19 13 15 15
39	30 26 22 24 20 11 9 9 17 15 9 20 19 19 15 15 15
42	26 24 15 9 9 13 19 19 19 15 19 19
45	19 13 15 9 7 9 19 20 26 15 17 19
48	11 11 15 7 7 6 22 26 30 15 20 20
51	15 13 13 9 11 32 28 26 17 20 19
54	11 9 11 24 24 32 30 30 32
57	7 15 19 30 28 13 20 24 30
60	9 9 6 17 15 15 28 30 28
63	7 17 13 13 13 11 26 30 28
66	11 9 9 30 28 32
69	11 17 19 30 30 35
72	19 20 20 32 30 24
75	17 20 26 22 20 11
78	26 24 26 11 7 9
81	19 11 20 11 11 15
84	26 28 28 11 11 26
87	24 11 11 26 20 19
90	11 11 20 15 13 11
93	20 17 9 13 13 13
96	11 7 7 15 15 11
99	11 9 6 13 11 13
102	4 11 15 19 20 17
105	15 15 15 11 11 9
108	26 19 20 11 11 9
111	22 24 20 13 11 11
114	22 24 20 11 11 7
117	15 17 26 11 11 15
120	26 30 28 17 15 15
123	30 24 26 15 17 17
126	22 26 26 30 30 30
129	20 19 22 26 22 22
132	20 22 20 7 11 9
135	22 22 24 9 13 11
138	22 22 26 11 13 13
141	30 30 24 15 24 26
144	24 7 11 24 26 26
147	13 13 7 19 19 17
150	7 11 19 15 15 11
153	19 9 13 11 9 9
156	11 7 13 11 7 9
159	15 15 22 24
162	20 15 7

	NORTH	NNE	NE	ENE	EAST	ESE	SE	SSE	SOUTH	SSW	SW	WSW	WEST	WNW	NW	NNW
Total	1136	757	333	245	22	34	22	33	307	451	666	2913	2724	436	160	272
Average speed	18.0	19.9	19.6	17.5	11.0	6.8	11.0	11.0	12.3	11.6	13.3	18.6	16.8	13.6	11.4	14.3
[illegible]	63	38	17	14	2	5	2	3	25	39	50	157	162	32	14	19

WIND SPEED (km/h), FREQUENCY & PREVAILING DIRECTION — MARCH 78

HOURS	NORTH	NNE	NE	ENE	EAST	ESE	SE	SSE	SOUTH	SSW	SW	WSW	WEST	WNW	NW	NNW
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TOTAL	253	438	971	1655	585	40	76	161	181	513	1130	2531	3056	1000	503	198
AVERAGE SPEED	13.3	15.6	19.0	21.8	16.2	10.0	10.9	17.9	13.9	20.5	19.5	19.2	18.6	18.5	18.0	12.4
[illegible]	19	28	51	76	36	4	7	9	13	25	58	132	164	54	28	16
	NORTH	NNE	NE	ENE	EAST	ESE	SE	SSE	SOUTH	SSW	SW	WSW	WEST	WNW	NW	NNW

WIND SPEED (km/h), FREQUENCY & PREVAILING DIRECTION — APRIL 78

HOURS	NORTH	NNE	NE	ENE	EAST	ESE	SE	SSE	SOUTH	SSW	SW	WSW	WEST	WNW	NW	NNW
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TOTAL	1025	1151	2531	1351	501	39	11	23	57	109	648	682	2595	1954	1376	689
AVERAGE SPEED	15.3	18.0	20.6	19.6	17.3	19.5	11.0	7.7	11.4	18.2	24.0	24.4	24.5	25.1	19.9	18.6
[illegible]	67	64	123	69	29	2	1	3	5	6	27	28	106	78	69	37
	NORTH	NNE	NE	ENE	EAST	ESE	SE	SSE	SOUTH	SSW	SW	WSW	WEST	WNW	NW	NNW

WIND SPEED (km/h), FREQUENCY & PREVAILING DIRECTION — MAY 78

HOURS	NORTH	NNE	NE	ENE	EAST	ESE	SE	SSE	SOUTH	SSW	SW	WSW	WEST	WNW	NW	NNW
TOTAL	297	1379	3255	443	138	130	265	630	1313	687	901	524	1158	859	665	254
[illegible]	12.9	18.9	22.6	17.7	13.8	11.8	14.7	16.6	14.9	16.4	20.0	15.4	17.3	17.9	19.6	16.9
[illegible]	23	73	144	25	10	11	18	38	88	42	35	34	67	48	34	15
	NORTH	NNE	NE	ENE	EAST	ESE	SE	SSE	SOUTH	SSW	SW	WSW	WEST	WNW	NW	NNW

WIND SPEED (km/h), FREQUENCY & PREVAILING DIRECTION — JUNE 78

HOURS	NORTH	NNE	NE	ENE	EAST	ESE	SE	SSE	SOUTH	SSW	SW	WSW	WEST	WNW	NW	NNW
TOTAL	222	198	192	98	60	94	155	459	1528	1460	1137	658	2358	2076	745	73
[illegible]	13.9	13.2	12.0	12.3	2.6	11.8	11.9	11.5	15.9	17.8	20.7	13.7	17.7	18.9	16.9	9.1
[illegible]	16	15	16	8	7	8	13	40	96	82	55	48	133	110	44	8
	NORTH	NNE	NE	ENE	EAST	ESE	SE	SSE	SOUTH	SSW	SW	WSW	WEST	WNW	NW	NNW

WIND SPEED (km/h), FREQUENCY & PREVAILING DIRECTION

JULY 78

HOURS	NORTH	NNE	NE	ENE	EAST	ESE	SE	SSE	SOUTH	SSW	SW	WSW	WEST	WNW	NW	NNW
1,2,3	9 13 11	11 11 11	17 13 13	7 19 17	11 11 11	11 9 9	7	9 11 15	9 15 13	7 17 17	7 13 13	6 6 6	9 7 30	6 24 12	26 11 15	9 6 4
4,5,6	9 6 11	11 6 11	13 20 20	17 19 15	22 6 9	9 7 9		7 15	9 11 8	7 7 19	11 9 9	7 9 7	26 26 28	20 30 32	19 17 15	11 13 13
9	11 11 15	13 9 19	22 28 30	9 11 13	7 15 11				19 22 26	22 24 28	9 7 11	7 13 11	24 15 22	24 24 28	17 20 7	13 11 11
12	15 11 19	20 13 15	30 30 19	28 26 24	9 6				7 15 22	26 26 19	11 24 22	11 11 17	15 9 11	32 30 30	17 13 15	15 6 13
15	17 15 13	13 9 6	19 17 17	26 15 11					33 19 13	13 19 15	19 15 6	11 15 19	11 19 11	30 17 19	15 6 17	15 15 9
18	15 13 9	11 7 17	19 19 17	13 15 15					15 11 17	11 11 19	9 20 17	13 11 11	30 26 30	17 15 13	7 15 26	13 16 6
21	17 15 15	13 17 19	11 13 22	17 11 22					22 22 22	22 24 38	22 23 37	11 9 7	15 11 15	13 15 13	28 24 20	7 7 6
24	15 11 11	19 13 15	26 22 17	15 15 30					11 28 15	26 28 24	13 19 11	9 15 15	13 13 9	19 19 7	17 6 11	7 11 19
27	7 6 20	22 18 15	17 17 15	19 7 9					15 6 15	22 24 22	11 11 7	9 15 11	6 7 17	9 11 7	19 19	17 17 17
30	15 15 15	13	13 15 17	6 17 15					28 20 19	22 15 30	9 26 17	11 9 13	15 13 13	13 9 26		26 17
33	9 9 7		17 17 15	9 15 15					20 11 11	26 35 24	13 6 19	15 17 19	11 9 9	11 19 13		
36	17 15 9		17 15 20	20 19 11					11 11 13	22 19 11	20 19 22	20 19 11	6 11 7	26 7 9		
39	19 17 20		22 30 26	6					11 13 13	13 7 17	24 22 11	9 8 26	7 9 6			
42	13 17 17		26 20 15						17 20 22	22 13 11	26 22 11	15 17 22	22 6 17			
45	9 15		9 9 7						24 22 26	33 33 26	13 9 20	9 9 7	7 19 28			
48			17 15 15						11 9 20	17 17 11	13 15 9	22 22 20	30 30 28			
51			7 19 15						20 22 17	13 9 13	17 26 22	15 28 32	9 11 15			
54			13 11 11						13 11 24	13 17 17	22 22 20	30 13 26	15 11 13			
57			9 11 9						15 13 11	17 19 26	13 11 9	20 22 30	9 11 6			
60			7 11 9						11 11 15	22 11 11	15 26 7	28 26 20	15			
63			9 6 15						20 9 11	11 7 17	9 9 20	30 7 13				
66			26 15 13						11 7 9	17 17 19	22 30 15	15 11 11				
69			13 13 15						9 11 17	20 19 9	17 30 26	19 9 7				
72			17 13 13						22 20 26	9 7 7	30 17 13	22 11 7				
75			9 11 11						7 11 20	6 13 13	11 22 26					
78									26 24 19	15 22 19	30 28 35					
81									13 9 11	20 22 22	28 20 19					
84									11 19	22 26 22	22 26 26					
87										19 19 26	20 20 17					
90										19 13 15	28 13 15					
93										11 19 15	7 22 24					
96										20 24 28	15					
99										6 15 7						
102										28 24 35						
105										30 30						
TOTAL	578	377	1246	578	118	53	7	57	1393	1982	1724	1090	964	649	412	360
AVERAGE SPEED	13.1	13.5	16.0	15.6	10.7	8.8	7	11.4	16.2	18.5	17.8	14.5	15.8	18.0	15.8	12.4
TOTAL HRS.	44	28	78	37	11	6	1	5	86	107	97	75	61	36	26	29
	NORTH	NNE	NE	ENE	EAST	ESE	SE	SSE	SOUTH	SSW	SW	WSW	WEST	WNW	NW	NNW

WIND SPEED (km/h), FREQUENCY & PREVAILING DIRECTION

AUGUST 78

HOURS	NORTH	NNE	NE	ENE	EAST	ESE	SE	SSE	SOUTH	SSW	SW	WSW	WEST	WNW	NW	NNW
1,2,3	7 9 11	19 7 7	13 9 7	7 13 9	13 9 9	7 7 11	11 6	9 9 7	7 9 30	7 7 17	9 6 6	7 30 30	11 7 6	11 9 17	9 5 6	13 11 6
4,5,6	9 4 6	4 13 20	7 5 9	13 11 19	7 11 11	7 7 7		9 9 7	11 11 19	19 19 22	9 9 30	22 9 9	15 13 15	15 4 6	9 6 13	4 11 9
9	4 11 6	7 7 6	7 7 6	11 11 7	11 7 6	7		13 11 11	13 13 4	26 30 30	20 9 11	7 7 17	20 15 13	6 6 9	9 9 7	9 33 17
12	7 17 19	6 9 13	13 13 19	15 9 9	11 4 7			11 11 11	7 9 9	7 11 13	6 9 6	11 4 15	4 6 4	7 11 13	11 11 11	6 7 7
15	20 11 9	11 11 9	17 13 15	15 11 13	13 13 7				9 7 7	19 22 26	7 13 20	11 7 11	7 4 6	28 22 11	9 7 4	7 9 9
18	9 6 7	11 9 7	15 15 17	13 6 6	6 6 11				13 11 15	30 30 26	17 22 20	4 22 30	7 6 6	28 28 30	26 17 19	11 7 11
21	7 13 7	9 6 17	9 9 7	7 11 7	6 7				11 7 7	32 30 30	30 30 33	30 22 24	22 11 9	28 24 20	7 28 6	
24	4 11 17	15 11 13	11 7 4	7 15 28					6 15 13	22 11 15	33 26 22	28 4 9	13 3 7	20 9 6	4 19	
27	9 6	11 7 11	4 9 11	11 7 17					15 17 24	13 15 11	24 24 20	7 7 11	9 7 9	22 26 6		
30		9 13 17	13 15 11	20 19 17					28 11 11	17 11 7	19 20 20	7 9 9	15 11 9			
33		11 13 15	11 11 7	11 7					9 15 15	4 7 17	20 19 20	7 13 13	11 7 6			
36		17 17 17	11 15 15						13 17 19	17 19 7	19 24 22	13 9 9	7 11 9			
39		17	13 9 6						22 15 13	9 7 11	22 24 28	11 9 9	26 26 32			
42			19 15 7						11 15 19	6 6 7	11 13 9	11 26 22	26 33 28			
45			1 7 15						13 7 9	22 19 17	7 13 13	22 28 22	28 22 24			
48			7 9 11						11 15 15	24 28 19	11 7 9	13 22 20	9 11 11			
51			9 15 28						19 22 6	28 37 32	26 15 44	24 24 22	13 11 7			
54			26 30 26						22 11 15	20 15 20	46 48 48	24 28 6	9 4 26			
57			22 28 26						7 15 13	19 28 33	41 30 22	11 17 15	24 28 17			
60			19 4 9						7 6 11	30 35 35	9 24 30	11 11 11	17 32 32			
63			9 13 17							15 9 9	28 9 11	11 11 9	24 24 30			
66			19 22 24							11 11 17	11 6 20	11 9 13	30 24 30			
69			26 30 30							24 9 15	20 15 15	15 15 19	19 15 9			
72			28 26 30							7 6 15	11 11 13	20 20 15	9 9 9			
75			26 20 20							20 22 20	11 15 9	11 28 24	7 11 7			
78			15 17 15							32 15 11	7 20 28	28 30 13				
81			11 7 13							6 6	30 28 30	22 22 9				
84											13 15 15	7 7 7				
87											19 7 6	9 7 19				
90											17 13 13	15				
TOTAL	246	422	1209	370	175	53	17	118	776	1432	1832	1491	1094	422	256	187
AVERAGE SPEED	9.5	11.4	14.4	11.6	8.8	7.6	8.5	9.8	12.9	17.9	20.4	16.9	14.6	15.6	11.1	10.4
TOTAL HRS.	26	37	84	32	20	7	2	12	60	80	90	88	75	27	23	18
	NORTH	NNE	NE	ENE	EAST	ESE	SE	SSE	SOUTH	SSW	SW	WSW	WEST	WNW	NW	NNW

WIND SPEED (km/h), FREQUENCY & PREVAILING DIRECTION

SEPTEMBER 78

	NORTH	NNE	NE	ENE	EAST	ESE	SE	SSE	SOUTH	SSW	SW	WSW	WEST	WNW	NW	NNW
TOTAL	610	603	1084	2002	452	129	163	449	529	956	1510	905	746	348	320	472
AVERAGE SPEED	13.0	13.7	18.4	18.7	13.3	12.9	10.2	16.6	15.1	16.2	18.9	16.5	17.0	15.1	16.8	15.7
[illegible]	47	44	59	107	34	10	16	27	35	59	80	55	44	23	19	30

WIND SPEED (km/h), FREQUENCY & PREVAILING DIRECTION

OCTOBER 78

	NORTH	NNE	NE	ENE	EAST	ESE	SE	SSE	SOUTH	SSW	SW	WSW	WEST	WNW	NW	NNW
TOTAL	404	605	417	158	207	127	82	180	1047	1819	2052	1351	1455	826	460	543
AVERAGE SPEED	13.9	17.3	20.9	13.2	10.4	11.5	13.7	13.9	15.8	17.5	15.6	16.9	16.2	16.9	14.8	19.4
[illegible]	29	35	20	12	20	1[illegible]	6	13	68	104	130	80	90	49	31	28

WIND SPEED (km/h), FREQUENCY & PREVAILING DIRECTION

NOVEMBER 78

HOURS	NORTH · NNE · NE · ENE · EAST · ESE · SE · SSE · SOUTH · SSW · SW · WSW · WEST · WNW · NW · NNW
1,2,3	9 11 7 7 11 15 6 9 4 13 13 19 6 7 13 6 15 15 30 20 7 11 13 7 6 11 15 11 13 9 11 19 28 33 24 6 13 7 11 7 6 24 24 20 13 6 11
4,5,6	11 6 9 20 20 28 13 13 13 24 19 20 13 19 20 11 30 39 11 9 13 9 15 15 19 24 20 11 11 7 22 9 13 13 15 9 20 17 17 13 19 6
9	17 15 15 26 26 24 19 15 11 11 15 13 15 15 15 28 15 13 11 13 19 28 22 20 24 19 13 7 19 11 37 33 24 6 15 7 7 15 13 9
12	15 7 9 24 9 11 9 26 26 11 13 13 [illegible] 17 11 11 11 7 15 9 13 28 28 17 6 22 9 35 28 26 28 24 7 6 13 4 6 7 7
15	7 9 7 6 20 24 28 28 32 7 7 11 15 13 9 11 13 19 11 4 15 13 9 6 17 20 15 22 24 19 24 26 26 6 30 19
18	7 7 15 28 22 26 26 33 28 11 11 20 6 19 15 15 17 9 17 11 11 9 9 9 26 32 32 17 17 15 26 19 22 22 22 22
21	7 7 7 26 24 24 30 24 28 19 13 15 13 11 11 7 9 7 15 13 19 7 9 7 13 13 15 11 13 11 20 19 24 24 20
24	17 15 15 24 13 7 15 17 20 11 9 11 9 9 9 22 13 9 11 13 11 11 9 13 13 11 7 4
27	15 17 15 9 15 17 17 17 15 9 11 13 9 11 15 7 9 19 11 7 6 13 56 57 37 28 24
30	13 13 13 22 30 22 15 15 15 9 9 11 19 22 24 22 15 19 6 4 20 59 59 57 20 22 26
33	15 15 17 26 17 19 11 20 15 11 9 7 28 26 24 13 17 13 30 22 24 59 61 56 26 26 15
36	15 9 7 13 19 20 11 22 19 9 7 11 19 15 15 7 13 19 22 22 13 48 43 37 13 9 11
39	9 20 20 20 9 9 17 22 20 17 20 19 20 19 19 15 24 22 6 7 6 37 41 37 11 24 24
42	15 19 23 9 11 11 17 15 11 26 30 35 19 20 19 20 22 22 11 30 26 24 26 20 19 20 17
45	22 22 20 26 19 22 9 7 11 30 30 32 19 22 24 24 24 26 30 28 9 20 17 22 20 30 28
48	22 19 20 22 9 9 7 33 33 22 15 13 30 30 7 11 52 56 20 20 24 28 26 26
51	19 17 9 7 7 9 19 19 22 6 7 6 17 17 20 28 28 28 32 30 32
54	9 7 6 24 22 7 7 26 30 22 26 33 28 28 30 30 32 28
57	7 7 9 9 6 4 20 32 30 7 13 11 28 32 24 24 26 17
60	11 11 13 6 9 7 30 26 28 17 37 32 26 20 15 13 11 20
63	17 19 13 24 30 28 32 28 15 28 26 30 19 22 24 13 15 13
66	13 17 30 20 37 41 9 11 15 33 11 26 33 30 22 24 30
69	33 32 28 33 41 41 26 28 32 26 30 24 19 13 28
72	30 30 26 28 17 28 26 24 26 20 32 28 33
75	19 22 22 30 28 28 9 15 17 33 35 33
78	20 19 15 33 9 32 24 28 35 33 30
81	28 19 19 28 17
84	11
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102	
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222	
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228	
231	
234	
237	
240	
243	
246	
249	
252	
255	

	NORTH	NNE	NE	ENE	EAST	ESE	SE	SSE	SOUTH	SSW	SW	WSW	WEST	WNW	NW	NNW
TOTAL	204	907	852	1204	731	36	50	139	1194	1427	1193	2140	1745	365	367	125
AVERAGE SPEED	917	17.8	18.5	15.4	15.6	12.0	25.0	19.9	17.1	18.5	18.4	26.1	21.8	18.3	16.7	10.4
[illegible]	21	51	46	78	47	3	2	7	70	77	65	82	80	20	22	12

WIND SPEED (km/h), FREQUENCY & PREVAILING DIRECTION

DECEMBER 78

HOURS	NORTH · NNE · NE · ENE · EAST · ESE · SE · SSE · SOUTH · SSW · SW · WSW · WEST · WNW · NW · NNW
1,2,3	9 9 6 7 9 9 9 11 9 11 22 22 13 19 22 9 9 6 9 6 17 24 20 20 24 24 9 17 26 15 13 13 17 17 15 19 22 22 20 26 17 17 7 13 7 4 15 13
4,5,6	7 6 19 19 9 7 9 6 24 24 26 24 17 22 33 7 15 13 7 24 30 6 13 24 6 20 22 32 17 15 11 20 20 15 22 20 7 20 9 22 9 17 17 11 7 6
9	22 22 26 9 7 7 20 15 15 19 19 15 7 4 11 4 6 6 30 6 13 30 22 24 15 17 24 19 20 33 17 13 9 13 6 11 7 4 17
12	11 11 9 7 13 6 11 9 11 7 4 9 11 15 19 15 17 24 30 30 17 7 11 11 22 24 6 11 11 15 11 9 20 13 11
15	13 13 9 7 6 7 11 6 9 9 15 22 24 30 30 30 15 26 30 28 22 20 15 9 15 11 11 13 17 15
18	11 6 7 22 26 28 11 15 11 19 19 19 37 33 28 26 28 33 11 9 13 26 28 28 13 13 7
21	9 6 13 20 20 19 9 20 19 26 28 24 38 37 41 44 43 52 15 13 11 37 43 46 11
24	13 13 13 11 9 19 24 11 13 28 28 30 15 7 9 46 46 44 11 26 30 48 37 33
27	15 17 20 22 7 6 7 30 30 13 26 11 24 43 28 28 30 28 30 44 52 48
30	26 26 24 4 7 4 20 28 22 15 30 30 24 28 33 28 32 28 41 46 52
33	22 13 17 7 6 6 28 11 15 30 30 33 35 41 37 26 28 32 48 37 26
36	13 15 11 6 7 6 15 22 6 37 41 37 28 37 37 33 33 44 22 15 15
39	13 15 15 11 7 11 9 28 37 37 37 32 32 30 35 30 32 9 11 39
42	17 11 13 33 35 37 35 39 32 22 24 22 13 20 17 9 11 30
45	11 13 13 35 6 6 33 41 37 20 24 22 26 24 46 37
48	11 7 7 4 4 13 20 33 41 15 19 13 41 35 41
51	11 11 20 15 13 11 37 44 37 7 11 11 37 37 37
54	22 26 26 11 9 9 44 37 19 17 17 17 37 37 30
57	26 19 15 22 15 13 22 9 13 9 26 30 19
60	13 17 15 22 29 11 11 11 30 22 20 32
63	11 11 17 11 46 46 30 28 24 37 37 30
66	9 4 9 32 26 26 24 28 28 52 35 35
69	6 20 15 28 28 28 30 38 28
72	13 11 6 24 24 22 17 22 22
75	4 6 6 28 22 22 6 30 35
78	9 17 30 14 44 51 58
81	15 22 20 46 39 37
84	15 17 19 37 28 28
87	17 19 19 24 20 26
90	20 20 22 30 24 22
93	24 26 28 20 17 33
96	30 28 28 37 41 37
99	24 28 41 37 37 30
102	37 35 35 33 28 28
105	37 46 48 22 28 28
108	41 46 30 30 28 30
111	37 43 41 26 26 30
114	50 39 37 17 17 13
117	41 46 37 13 9 13
120	41 41 33 11 7
123	30 28 30
126	32 32 24
129	19 17 19
132	17 22 32
135	30 7 17
138	17 43 41
141	44 52 44
144	13 15 15
147	26 22 19
150	19 28 20
153	26 22 33
156	30 33 28
159	32 33 32
162	30 30 32
165	30 26 24
168	24 24 19
171	17 6 26
174	28 28 20
177	24 9 9
180	15 19 20
183	24 26 22
186	22 26 30
189	30 26 26
192	28 28 30
195	19 17 20
198	17 20 24
201	30 30 28
204	30 26 20
207	20 17 17
210	9 6 7
213	6 4 4
216	
219	
222	
225	
228	
231	
234	
237	
240	
243	
246	
249	
252	
255	

	NORTH	NNE	NE	ENE	EAST	ESE	SE	SSE	SOUTH	SSW	SW	WSW	WEST	WNW	NW	NNW
TOTAL	148	125	279	1050	431	31	71	130	106	1067	1954	5423	3146	1135	157	218
AVERAGE SPEED	13.5	9.6	11.2	15.9	11.3	7.8	10.1	18.6	15.1	19.4	25.7	25.5	26.4	26.4	11.2	11.5
[illegible]	11	13	25	66	38	4	7	7	7	55	76	213	119	43	14	19

WIND SPEED (km/h), FREQUENCY & PREVAILING DIRECTION

JANUARY 79

HOURS	NORTH	NNE	NE	ENE	EAST	ESE	SE	SSE	SOUTH	SSW	SW	WSW	WEST	WNW	NW	NNW
1,2,3 … 255	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TOTAL	402	261	528	1247	537	66	43	13	17	151	1428	3874	3805	1306	1052	652
Average speed	13.4	15.4	21.1	17.8	13.1	13.2	10.8	6.5	5.7	21.6	23.4	26.7	25.7	22.1	19.8	14.8
[illegible]	30	17	25	70	41	5	4	2	3	7	61	145	148	59	53	44
	NORTH	NNE	NE	ENE	EAST	ESE	SE	SSE	SOUTH	SSW	SW	WSW	WEST	WNW	NW	NNW

WIND SPEED (km/h), FREQUENCY & PREVAILING DIRECTION

FEBRUARY 79

HOURS	NORTH	NNE	NE	ENE	EAST	ESE	SE	SSE	SOUTH	SSW	SW	WSW	WEST	WNW	NW	NNW
1,2,3 … 255	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
TOTAL	817	1562	1117	1637	692	66	107	95	303	485	1106	1077	2216	841	923	355
Average speed	16.3	22.0	29.4	20.7	16.5	7.3	8.9	8.6	10.8	18.7	20.1	20.7	27.7	26.3	22.5	15.4
[illegible]	50	71	38	79	42	9	12	11	28	26	55	52	80	32	41	23
	NORTH	NNE	NE	ENE	EAST	ESE	SE	SSE	SOUTH	SSW	SW	WSW	WEST	WNW	NW	NNW

WIND SPEED (km/h), FREQUENCY & PREVAILING DIRECTION

MARCH 79

HOURS	NORTH	NNE	NE	ENE	EAST	ESE	SE	SSE	SOUTH	SSW	SW	WSW	WEST	WNW	NW	NNW
1,2,3	6 4 4	17 11 7	17 17 19	11 20 9	7 11 9	9 7 7	11 9 30	7 4 20	9 17 28	15 17 19	17 13 20	9 7 6	11 15 17	28 28 33	15 6 32	33 9 4
4,5,6	19 9	7 9 11	22 22 15	7 11 7	11 11 11	9 7 9	20 24 15	11 15 13	24 28 37	11 11 11	11 26 22	26 26 26	15 9 11	20 26 26	35 30 32	20 13 22
9		9 9 9	19 19 20	9 17 15	13 9 11	6 6 7	19 19 11	17 17 15	41 41 41	19 17 24	30 24 20	26 30 41	15 11 15	22 35 33	30 26 26	
12		6 7 6	19 22 17	17 19 22	7 15 20		13	17 19 17	37 30 26	26 17 11	19 19 19	33 32 30	15 11 11	26 32 37	20 20 19	
15		7 4 4	19 20 22	19 19 15	19 6 9			24 22 24	9 13 11	11 15 15	7 15 28	22 19 24	26 24 32	26 33 30	11 28 19	
18		9 9 4	17 11 7	11 15 9	7 6 6			7 4 17	11 9 15	15 11 9	19 17 26	11 30 19	22 19 6	19 20 17	20	
21			11 13 19	19 15 19	13 9 9			6 20 17	11 11 13	24 30 37	32 33 30	26 26 26	30 33 22	22 28 30		
24			22 17 13	13 15 7	26 9 4			20 26 15	15 11 6	37 39 41	7 46 48	26 26 30	30 24 22	13 19 17		
27			15 17 11	4 9 17	4 9 9			15 15 17	7 6 6	41 39 33	37 30 41	37 37 32	28 28 33	17 22 28		
30			15 11 11	15 6 17	11 15 11			30 19 22	15 11 15	30 37 32	44 41 15	35 11 46	30 30 33	26 30 13		
33			17 19 17	13 6 11	9 9 9			19 6	9 6 13	32 20 19	15 20 19	46 33 17	33 28 28	15 17 15		
36			11 15 15	17 11 26	13 9 7				11 15 19	26 26 22	15 13 11	17 19 20	32 26 30	22 22 24		
39			15 15 11	26 26 26	7 11 9				4 20 17	22 22 32	9 24 28	20 22 22	30 28 26	26 19 15		
42			7 7 6	28 28 19	11 7				20 24 26	37 26 22	26 26 20	20 24 28	20 22 24	15 7 9		
45			11 6 9	13 9 6					24 22 11	13 13 26	17 20 17	33 33 33	33 33 30	32 28		
48			6 19 9	4 6 7					13 11 37		20 37 35	38 32 30	28 30 33			
51			7 15 11	11 7 7					4 7 4		30 22 28	37 28 22	30 30 33			
54			9 15 15	9 9 4					11 26 26		19 19	26 26 22	33 30 32			
57			28 24 30	7 15 6					11 7			20 15 17	26 17 39			
60			6 6 7	9 9 7								17 17 11	37 44 48			
63			4 13 17	9 13 15								13 13 11	44 48 37			
66			19 15 11	19 19 15								9 6 4	30 24 33			
69			11 6 9	17 13 19								7 7 9	37 37 33			
72			9 11 15	15 15 19								9 7 7	37 26 22			
75			17 19 17	11 11 19								17 15 17	22 37 13			
78			17 15 15	11 7								30 30 26	13 11 13			
81			15 17 13									30 32 32	7 4 15			
84			11 13 19									33 30 28	24 28 33			
87			13 11 9									30 30 30	30 30 9			
90												22 20 24	13 30 28			
93												20 11 24	24 33 33			
96												15 6 19	37 33 41			
99												19 19 15	37 39 33			
102												19 33 19	28 22 24			
105												19 26	15 17 20			
108													26 26 26			
111													20 20 9			
114													7 6 15			
117													22 22 37			
120													30 24 26			
123													22 19 19			
126–255																
TOTAL	42	145	1237	1037	416	78	171	513	952	1052	1236	2347	3122	1022	369	101
AVERAGE SPEED	8.4	8.1	14.2	13.5	10.1	7.8	17.1	16.0	17.0	23.4	23.3	22.6	25.4	23.2	23.1	16.8
TOTAL HRS	5	18	87	77	41	10	10	32	56	45	53	104	123	44	16	6
	NORTH	NNE	NE	ENE	EAST	ESE	SE	SSE	SOUTH	SSW	SW	WSW	WEST	WNW	NW	NNW

WIND SPEED (km/h), FREQUENCY & PREVAILING DIRECTION

APRIL 79

HOURS	NORTH	NNE	NE	ENE	EAST	ESE	SE	SSE	SOUTH	SSW	SW	WSW	WEST	WNW	NW	NNW
1,2,3	9 7 7	15 15 7	19 13 20	17 19 22	19 20 28	9 13 17	7 7 4	4 15 9	11 17 26	20 26 48	20 22 20	30 30 30	41 37 41	28 24 19	17 15 28	15 11 19
4,5,6	7 26 28	37 28 19	30 15 11	26 26 24	24 24 11	11 11 6	11 7 11	7 9 11	6 7 9	11 6 7	24 70 52	35 33 39	35 33 33	17 15 22	22 26 28	20 22 22
9	28 13 20	20 13 7	11 13 13	30 24 26	9 44 46	4 7 4	15 15	4 6 11	11 17 13	7 6 6	19 24 26	30 32 22	32 17 6	13 50 56	30 24 7	22 22 15
12	4 11 19	11 17 7	13 9 30	26 24 26	35 4 7	7 6 7		11 9 19	20 19 7	15 22 20	24 26 24	24 70 59	24 28 30	56 48 46	22 13 11	9 11 26
15	19 15 15	9 6 9	37 22 48	30 30 33	15 15 11	7 11 11		15 7 19	11 9 4	7 6 11	15 11 11	30 35 26	30 35 30	33 39 44	28 22 20	22 22 9
18	13 17 13		41 44 37	33 30 30	28 24 22			13	22 26 7	6 9 11	6 7 11	24 11 7	30 30 30	20 20 26	15 19 19	7 13 22
21	11 15 22		37 9 30	24 20 11	22 11 7				22 24 22	9 7 6	6 9 20	6 11 11	33 33 35	19 24 26	26 28 32	11 13 13
24	22 19 19		30 30 30	11 11 22	7 4 7				19 24 24		7 24 9	4 4 15	32 32 37	7 7 4	22 9 9	11 24 22
27	19 15 15		33 28 30	22 26 57	7 9 9				28 22 20		19 28 37	7 11 20	89 51 67	7 19 22	9 17 28	22 19 19
30	19 13 7		30 22 28	44 44 46	7 6 13				33 30 24		35 37 28	13 22 19	67 74 78	20 11 17	26 30 24	13 19 13
33	4 6 11		26 30 26	41 41 26	11				37 22 22			9 11 13	74 89 74	20 17 15	17 11 13	13 6 11
36	11 15		24 22 19	13 17 20					13 15 15			11 7 11	74 32 33	15 13 11	11 20 13	7 15
39			13 11 11	13 26 33					11 19 17			6 19 19	30 30 32	26 26 26	11 9 9	
42			7 9 7	37 35 39					11 11 19			19 35 44	30 26 24	30 30 24	4	
45			15 7 13	44 48 48								30 26	22 22 24	26 19 22		
48			7 6 11	44 41 46									15 13 9	26 20 24		
51			7 6 19	44 50 15									13 9 22	19 15 24		
54			20 11 7	17 22 24									19 15 15	20 15 15		
57			7 7 9	24 22 22									7 4 6	19 15 28		
60				26 24 26									56 30 11	28 7 24		
63				24 19 30									13 15 13	19 6 6		
66				22 26 24									11 6 9	22 20 22		
69				26 26 32									4 7 7	19 11 20		
72				30 32 30									9 13 19	19 17		
75				32 33 28									13 13 7			
78				37 30 32									7 11 11			
81				35 33 30									7 7 9			
84				32 32 28									7 4 9			
87				32 24 28									11 30 19			
90				28 30 30									15 22 22			
93				30 15 11									19 20 22			
96				13 15 9									20 22 22			
99				7 7 15									22 20 11			
102				11 11 7									20 20 17			
105				6 13 4									13 9 9			
108				19 19 9									13 17 15			
111				4 7									11 9 9			
114													11 15 20			
117													32			
120–255																
TOTAL	514	220	1120	2850	506	131	77	169	744	268	670	976	2857	1574	780	560
AVERAGE SPEED	14.7	14.7	19.6	25.9	16.3	8.7	9.6	10.6	17.7	12.8	22.3	22.2	26.2	22.2	18.5	16.0
TOTAL HRS	35	15	57	110	31	15	8	16	42	21	30	44	118	71	40	35
	NORTH	NNE	NE	ENE	EAST	ESE	SE	SSE	SOUTH	SSW	SW	WSW	WEST	WNW	NW	NNW

WIND SPEED (km/h), FREQUENCY & PREVAILING DIRECTION — MAY 79

HOURS	NORTH	NNE	NE	ENE	EAST	ESE	SE	SSE	SOUTH	SSW	SW	WSW	WEST	WNW	NW	NNW
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	277	704	2471	1210	454	30	34	84	991	832	909	625	1000	966	415	112
[illegible]	12.0	20.7	19.6	16.1	11.9	10.0	6.8	14.0	13.4	14.3	13.6	16.4	15.4	17.3	16.0	14.0
[illegible]	23	34	126	75	38	3	5	6	74	58	67	38	65	56	26	8
	NORTH	NNE	NE	ENE	EAST	ESE	SE	SSE	SOUTH	SSW	SW	WSW	WEST	WNW	NW	NNW

WIND SPEED (km/h), FREQUENCY & PREVAILING DIRECTION — JUNE 79

HOURS	NORTH	NNE	NE	ENE	EAST	ESE	SE	SSE	SOUTH	SSW	SW	WSW	WEST	WNW	NW	NNW
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	398	402	1120	458	380	77	76	227	914	1919	1736	1023	905	1136	634	305
[illegible]	13.3	16.8	16.5	15.3	10.6	9.6	9.5	18.9	15.5	16.3	18.1	20.1	18.1	19.3	17.6	17.9
[illegible]	30	24	68	30	36	8	8	12	59	118	96	51	50	59	36	17
	NORTH	NNE	NE	ENE	EAST	ESE	SE	SSE	SOUTH	SSW	SW	WSW	WEST	WNW	NW	NNW

WIND SPEED (km/h), FREQUENCY & PREVAILING DIRECTION

JULY 79

HOURS	NORTH	NNE	NE	ENE	EAST	ESE	SE	SSE	SOUTH	SSW	SW	WSW	WEST	WNW	NW	NNW
TOTAL	248	302	443	171	93	19	46	169	875	1571	1288	577	1077	995	719	369
AVERAGE SPEED	10.3	13.1	12.0	12.2	6.6	6.3	11.5	9.9	12.3	11.9	13.2	15.6	12.0	13.6	12.8	18.5
[illegible]	26	23	37	14	14	3	4	17	71	132	93	37	90	73	56	20
	NORTH	NNE	NE	ENE	EAST	ESE	SE	SSE	SOUTH	SSW	SW	WSW	WEST	WNW	NW	NNW

WIND SPEED (km/h), FREQUENCY & PREVAILING DIRECTION

AUGUST 79

HOURS	NORTH	NNE	NE	ENE	EAST	ESE	SE	SSE	SOUTH	SSW	SW	WSW	WEST	WNW	NW	NNW
TOTAL	169	357	941	1108	192	26	37	76	422	967	1436	1003	1543	707	540	291
AVERAGE SPEED	11.3	12.8	10.9	12.6	8.7	8.7	7.4	9.5	10.3	15.1	17.7	17.6	17.5	12.4	12.0	10.8
[illegible]	15	28	86	89	22	3	5	8	41	64	81	57	88	57	45	27
	NORTH	NNE	NE	ENE	EAST	ESE	SE	SSE	SOUTH	SSW	SW	WSW	WEST	WNW	NW	NNW

WIND SPEED (km/h), FREQUENCY & PREVAILING DIRECTION

SEPTEMBER 79

HOURS	NORTH	NNE	NE	ENE	EAST	ESE	SE	SSE	SOUTH	SSW	SW	WSW	WEST	WNW	NW	NNW
1,2,3	7 11 19	17 15 15	15 17 11	11 9 7	4 9 6	7 11	7 11 11 7	6 9 13	9 6 9	6 7 13	17 26 20	24 26 13	11 11 9	15 15 11	9 13 24	11 7 11
4,5,6	15 15 19	7 11 15	11 13 15	9 11 9	4 6 5	4 4		7 7 11	19 19 19	15 19 17	22 26 35	15 11 7	9 13 17	13 20 28	20 35 30	11 11 4
9	11 15 17	11 6 7	19 11 13	4 7 6	9 4 6			9 7 7	19 19 11	15 15 19	19 19 17	24 19 9	17 17 17	20 11 11	13 13 15	13 22 19
12	15 19 20	19 15 20	13 6 13	7 11 19	9 11 9			6 13 7	7 9 15	22 26 22	15 11 11	9 9 9	15 19 24	15 11 15	22 15 15	11 11 11
15	19 22 11	22 15 20	7 9 11	19 15 15	11 9 7			6 4	17 20 20	26 20 15	15 6 17	13 15 24	26 30 26	28 22 20	19 15 9	4 30 20
18	6 7 7	26 24 15	11 19 15	13 11 11	4 7 6				11 7 15	20 15 17	24 41 44	6 9 11	32 26 11	17 13 11	4	15 15 22
21	28 20 19	11 7 13	15 13 13	11 7 11	19 11 9				13 11 6	19 13 11	17 39 20	11 7 7	9 11 22	11 22 15		15 17 17
24	17 20 20	6 15 13	17 15 11	22 15 11	4 6 4				7 7 11	7 7 11	26 26 19	7 11 19	17 9 11	19 19 17		20 11 13
27	15 13 15	19 28 17	11 11 13	19 19 17	4 6 6				20 19 22	11 6 11	24 11 9	26 28 28	11 7 9	7 9		11 7 17
30	7 4 19	11 13 13	11 7 7	19 15 15					30 9 11	20 26 33	24 15 19	28 26 28	13 7 11			13 7 6
33	13 11 13	22 17 13	11 9 7	17 9 9					22 19 19	30 20 6	15 11 7	32 24 20	15 26 22			6
36	19 15 11	15 13 7	15 17 11	6 6 24					20 19 6	7 17 6	11 6 6	19 30 11	19 19 19			
39	11 7 11		6 4 7	24 19 22					7 7 9	17 30 32	7 28 26	9 6 9	24 15 17			
42	15 15 19		7 6 2	19 22 19					17 17 19	32 13 13	28 28 20	7 9	11 9 7			
45	13 9		28 19 17	19 9 11					9 4 7	9 11 13	15 11 13		9 9 9			
48			7 13 9	15 11 11					11 7 19	17 20 15	13 15 19		9 9 9			
51			17 26 22	11 11 9					13 6 7	7 7 7	19 19 17		17 30 26			
54			7 11 9	13					7 13 11	13 7 9	20 13 28		11 15 7			
57			7 6 7						11 9 11	19 19 22	30 30 30		19 11 19			
60			19 19 7						11 13 6	19 19 19	30 28 35		9 9 9			
63			20 30 24						6 4 4	15 17 17	13 28 19		11 11 11			
66			20 17 13						13	17 17 19	15 15 15		11 9 9			
69			19 19 22							17 15 9	11 11 13		9 7 9			
72			9 9 15							7 15 13	17 24 7		9 4 7			
75			7 13 9							17 19 20	7 11 11		8 4 7			
78			11 13							19 15	20 26 26		2 6			
81											22 15 11					
84											11 6 9					
87											11 9 11					
90											11 11 9					
TOTAL	313	533	985	691	196	39	29	112	806	1227	1641	665	1024	415	271	408
AVERAGE SPEED	7.1	14.8	12.8	13.3	7.3	6.5	9.7	8.0	12.6	15.9	18.2	16.2	13.3	16.0	16.7	13.2
[illegible]	44	36	77	52	27	6	3	14	64	77	90	41	77	26	16	31
	NORTH	NNE	NE	ENE	EAST	ESE	SE	SSE	SOUTH	SSW	SW	WSW	WEST	WNW	NW	NNW

WIND SPEED (km/h), FREQUENCY & PREVAILING DIRECTION

OCTOBER 79

HOURS	NORTH	NNE	NE	ENE	EAST	ESE	SE	SSE	SOUTH	SSW	SW	WSW	WEST	WNW	NW	NNW
1,2,3	13 22 11	13 11 9	11 13 15	11 11 11	13 9 6	11 15 17	19 11 13	6 17 22	9 26 24	11 19 17	11 7 9	13 13 22	19 11 9	30 32 30	6 7 7	7 19 26
4,5,6	13 7 22	11 22 19	11 9 11	11 9 15	9 9 11	13	20 15 11	15 9 15	26 19 17	22 20 7	17 19 17	26 20 20	15 7 7	22 22 19	20 19 26	22 20 20
9	7 11	13 7 19	7 11 11	19 20 7	7 13 6			15 17 7	19 24 17	11 11 9	11 19 6	17 11 4	6 13 15	17 15 19	20 19 9	19 15 15
12		13 7 6	15 15 19	4 11 13	9 4 9			19 15 19	7 6 24	11 11 28	6 11 11	11 11 11	15 17 17	13 15 19	15 26 9	18 7 2
15		7 9 13	19 15 15	13 11 11	7 15 13			19	17 22 9	28 22 28	13 9 7	4 24 28	26 33 28	30 24 22	7 26 22	17 15 13
18		19 13 15	15 20 20	19 15 15	11 7 11				7 11 19	26 30 32	7 22 19	26 26 24	28 32 33	20 17 20	15 20 20	9 9
21		15 15 15	20 20 19	13 19 9	11 9 11				22 19 20	28 26 26	22 19 20	19 22 15	33 33 35	20 15 15	19 13 9	
24			19 22 22	9 13 11					17 13 15	19 11 11	28 11 9	17 24 7	24 13 17	11 17 19	7 7 6	
27			20 20 22	13 9 11					20 15 17	15 19 28	15 6 11	15 7 4	15 11 13	26 20 20	6 7	
30			20 26 22	19 13 13					13 17 11	24 28 26	7 11 9	7 11 7	13 11 11	28 22 19		
33			19 17 15	15 11 9					7 15 24	26 26 22	7 11 11	24 26 28	9 9 7	15 15 15		
36			11 9 15	9 4 7					24 24 22	28 28 30	11 15 15	30 33 20	6 7 7	13 15 13		
39			15 17 17	11 7 15					15 15 15	28 28 22	22 11 11	15 22 26	7 7 6	13 11 15		
42			20 22 26	15 22 19					17 22 22	24 28 20	11 13 11	28 24 20	7 9 13	22 20 30		
45			28 26 22	22 28 30					24 19 17	17 20 15	11 11 11	24 33 24	11 17 19	19 15 9		
48			22 24 22	26 22 24					15 13 11	15 15 11	9 11 15	28 32 17	20 22 43	7 7 7		
51			20 17 17	28 26 26					22 15 22	9 15 19	22 30 11	11 11 11	35 33 30	6 7 13		
54			19 15 15	30 28 15					22 7 17	26 30 30	9 13 11	22 26 30	32 26 28	11		
57			9 9 11	15 15 17					19 20	30 32 15	22 20 20	22 11 9	7 11 13			
60			9 9 19	26 11						20 28	17 28 22	7 7 11	13 13 17			
63			20 22 20								26 28 26	9 11 48	13 22 28			
66			19 15 11								26 35 44	37 37 28	15 24 15			
69			15 15 11								46 33 39	43 22 28	22 11 7			
72			17 19 13								24 20 13	26 28 26	7 7 7			
75			19 7 9								17 33 32	30 32 30	9 7 9			
78			28 24 20								41 44 52	26 33 35	30 44 37			
81			19 15 15								41 41 22	41 7 11	35 35 30			
84			15 17 15								26 28 28	17 26 24	26 19 17			
87			20 28 28								24 20 6	35 30 26	20 15 17			
90			30 28 28								6 7 11	30 20 24	13 13 11			
93			22								7 9 11	22 13	7 17 28			
96											7 11 9		26 33 19			
99													20 17 17			
102													15 13 11			
105													9 9			
TOTAL	106	271	1574	909	200	56	89	194	967	1251	1702	1923	1840	906	367	248
AVERAGE SPEED	13.3	12.9	17.3	15.4	9.5	14.0	14.8	14.9	17.1	21.2	17.7	20.9	17.7	17.4	14.1	14.6
[illegible]	8	21	91	59	21	4	6	13	56	59	96	92	104	52	26	17
	NORTH	NNE	NE	ENE	EAST	ESE	SE	SSE	SOUTH	SSW	SW	WSW	WEST	WNW	NW	NNW

WIND SPEED (km/h), FREQUENCY & PREVAILING DIRECTION — NOVEMBER 79

[illegible]

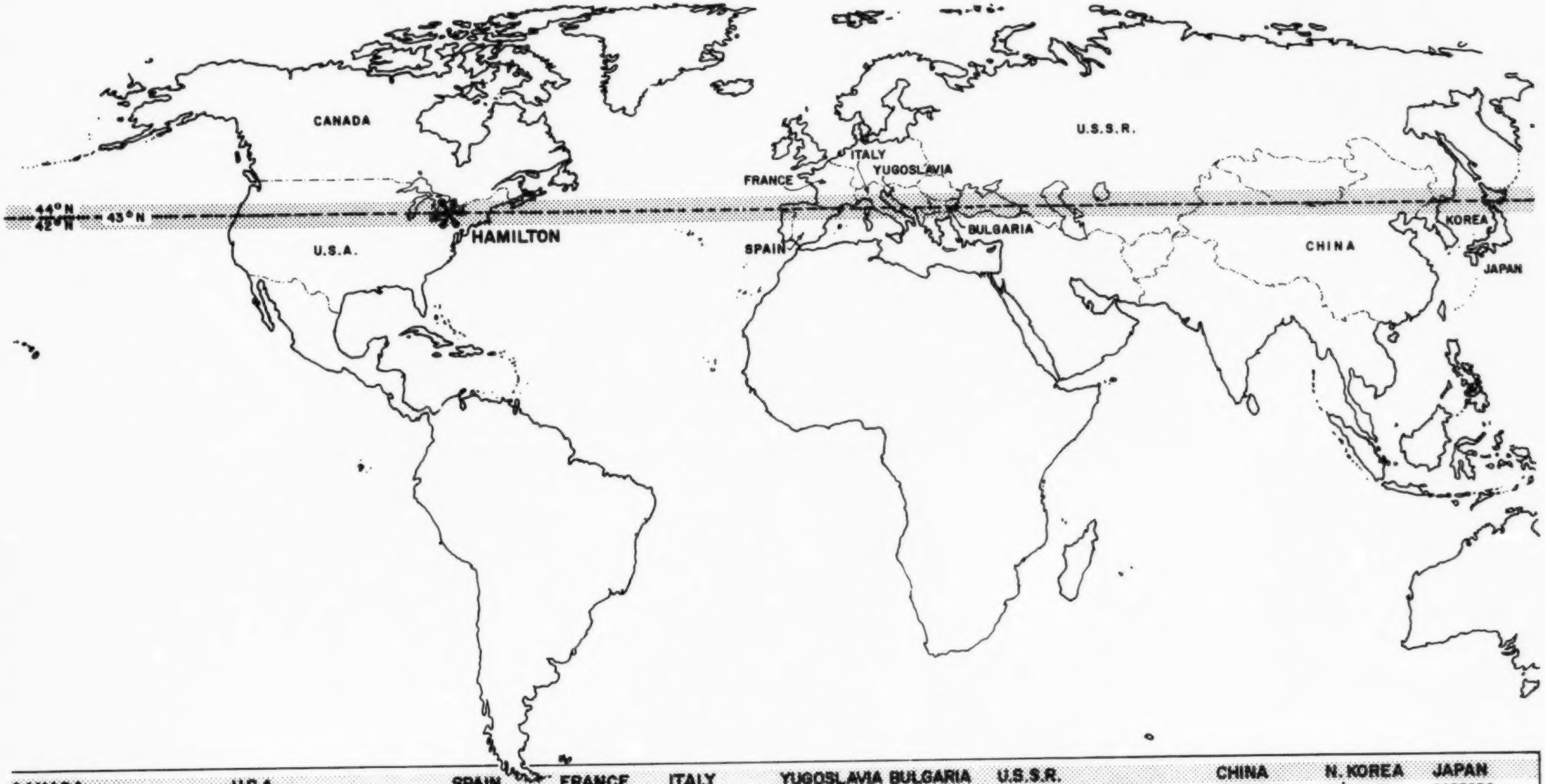
	NORTH	NNE	NE	ENE	EAST	ESE	SE	SSE	SOUTH	SSW	SW	WSW	WEST	WNW	NW	NNW
TOTAL	151	291	880	792	205	35	33	105	794	1229	1513	2177	2343	585	316	219
AVERAGE SPEED	13.7	12.1	16.0	16.5	11.4	11.7	8.3	9.6	15.3	18.3	19.6	14.5	20.6	16.7	13.7	14.6
[illegible]	11	24	55	48	18	3	4	11	52	67	77	150	114	35	23	15

WIND SPEED (km/h), FREQUENCY & PREVAILING DIRECTION — DECEMBER 79

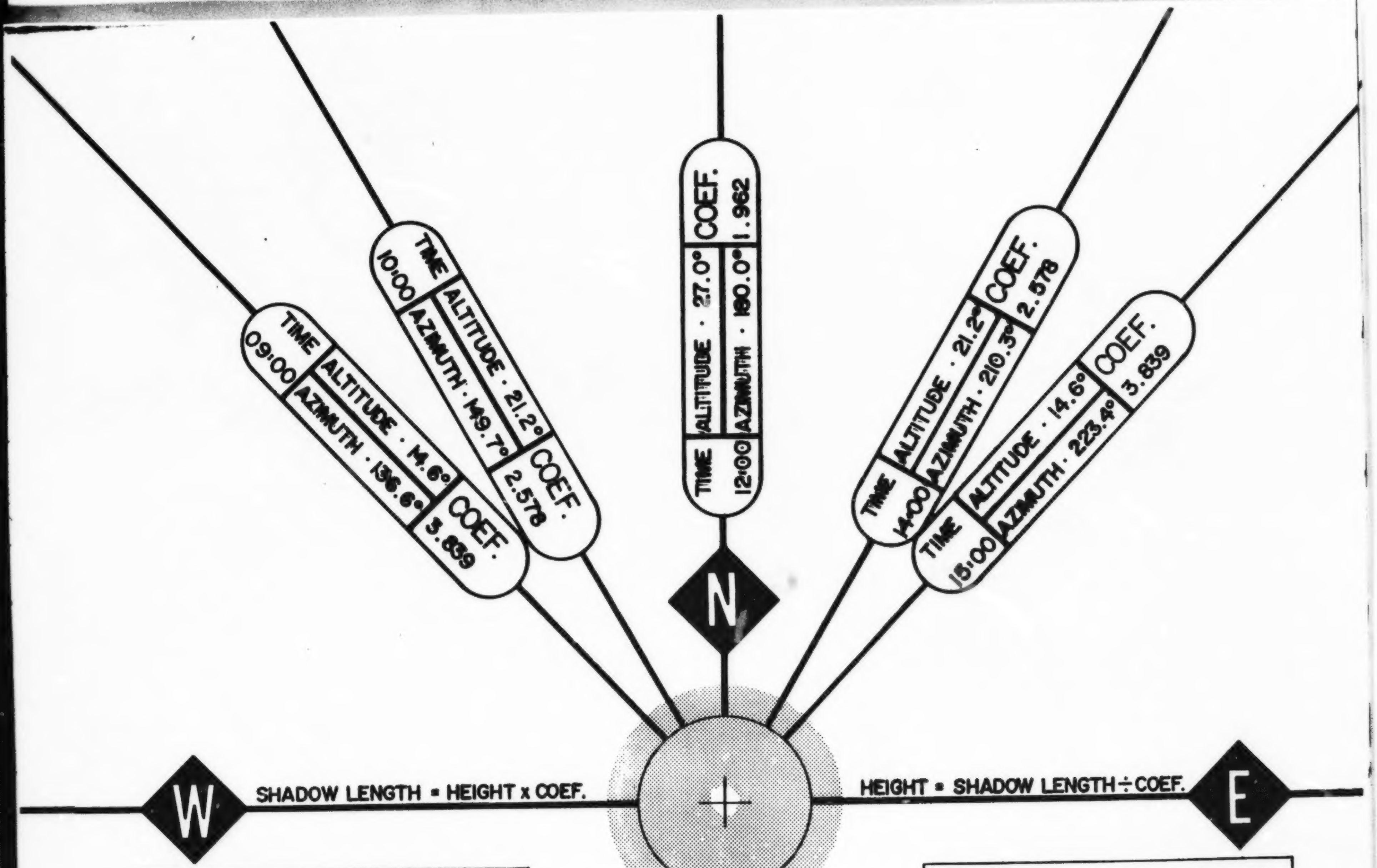
[illegible]

	NORTH	NNE	NE	ENE	EAST	ESE	SE	SSE	SOUTH	SSW	SW	WSW	WEST	WNW	NW	NNW
TOTAL	853	970	785	242	290	46	132	165	653	1910	2504	3282	2625	1010	791	441
AVERAGE SPEED	24.4	23.7	23.8	13.4	13.8	11.5	11.0	10.3	19.8	24.2	22.8	23.8	22.8	23.5	22.6	21.0
[illegible]	35	41	33	18	21	4	12	16	33	79	87	138	115	43	35	21

HAMILTON SHADOW TEMPLATE SET IS APPLICABLE FOR ANY CITY LOCATED BETWEEN 42°N AND 44°N LATITUDE



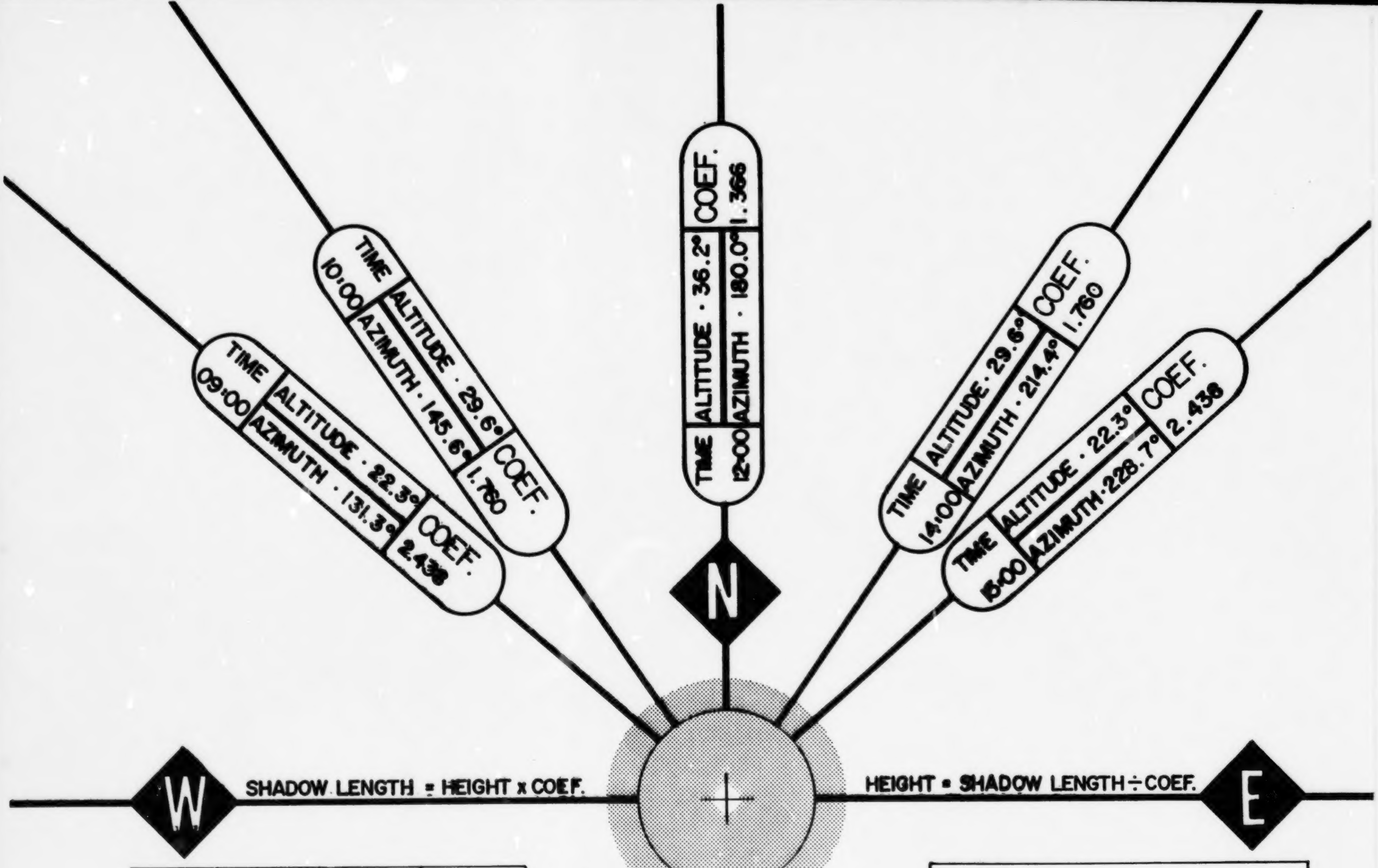
CANADA		U.S.A.		SPAIN	FRANCE	ITALY	YUGOSLAVIA	BULGARIA	U.S.S.R.		CHINA	N. KOREA	JAPAN
HAMILTON	GUELPH	BOSTON	DETROIT	BILBAO	NICE	ROME	SPLIT	SOFIJA	GROZNYJ	USSURIJSK	SHENYANG	CH'ONGJIN	SAPPORO
TORONTO	KITCHNER	CAMBRIDGE	WARREN	LA CORUNA	TOULOUSE	FIRENZE	SARAJEVO	RUSE	FRUNZE	SUCHUMI	FUSHUN		ASAHIKAWA
ETOBICOKE	WATERLOO	WORCESTER	LIVONIA	VIGO	MARSEILLE	FOLIGNO		VARNA	ALMA-ATTA	POTI	CHANGCHUN		OTARU
NORTH YORK	CAMBRIDGE	SPRINGFIELD	DEARBORN	OVIEDO	MONTPELLIER	LIVORNO			VLADIVOSTOK	MOZDOK	JILIN		MURORAN
SCARBOROUGH	BRANTFORD	ROCHESTER	FLINT	GIJON	NIMES	PRATO			SOCI	GORI	YINING		HAKODATE
NIAGARA FALLS	LONDON	BUFFALO	LANSING	SANTANDER	TOULON				KUTAISI	KIZL'AR	WULUMUQI		OBIHIRO
ST.CATHARINES	ST. THOMAS	ALBANY	GRAND RAPIDS	SAN SEBASTIAN					NAL'CIK		FUXINSHI		KUSHIRO
WELLAND	CHATHAM	UTICA	CHICAGO	PAMPLONA					ORDZONIKIDZE		SIPING		
BURLINGTON	WINDSOR	SYRACUSE	ROCKFORD						MACHACKALA		LIAOYUAN		
OAKVILLE	SARNIA	NIAGARA FALLS	MILWAUKEE						CIMKENT				
BRAMPTON		ERIE	MADISON						DZAMBUL				



SLOPE IN % AND DIRECTION		09:00 AND 15:00 HOURS	10:00 AND 14:00 HOURS	12:00 HOURS
1%	SOUTH	3.697	2.516	1.925
	NORTH	3.992	2.646	2.008
2%	SOUTH	3.566	2.443	1.869
	NORTH	4.156	2.716	2.043
3%	SOUTH	3.442	2.393	1.864
	NORTH	4.340	2.784	2.085
4%	SOUTH	3.328	2.337	1.820
	NORTH	4.536	2.875	2.130
5%	SOUTH	3.221	2.284	1.767
	NORTH	4.751	2.954	2.176

- FOR SLOPES GREATER THAN 5% USE FORMULA ON APPENDIX "B"
- EASTERN STANDARD TIME
- HAMILTON: 43 DEG. NORTH LATITUDE

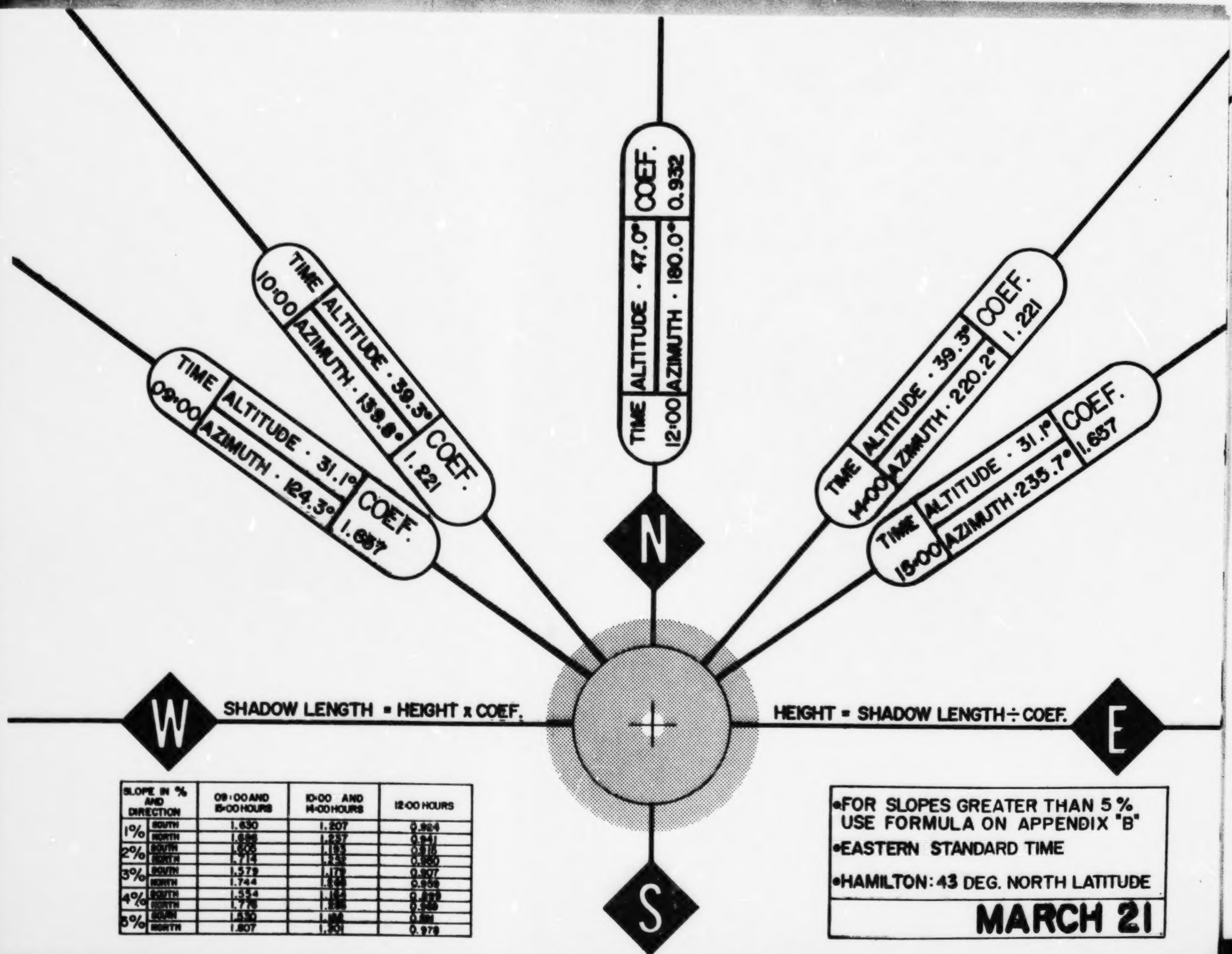
JANUARY 21



SLOPE IN % AND DIRECTION		09:00 AND 15:00 HOURS	10:00 AND 14:00 HOURS	12:00 HOURS
1%	SOUTH	2.380	1.729	1.348
	NORTH	2.499	1.792	1.385
2%	SOUTH	2.320	1.701	1.330
	NORTH	2.563	1.834	1.405
3%	SOUTH	2.272	1.672	1.313
	NORTH	2.631	1.858	1.425
4%	SOUTH	2.222	1.644	1.296
	NORTH	2.702	1.894	1.445
5%	SOUTH	2.173	1.815	1.279
	NORTH	2.777	1.868	1.467

- FOR SLOPES GREATER THAN 5 % USE FORMULA ON APPENDIX "B"
- EASTERN STANDARD TIME
- HAMILTON: 43 DEG. NORTH LATITUDE

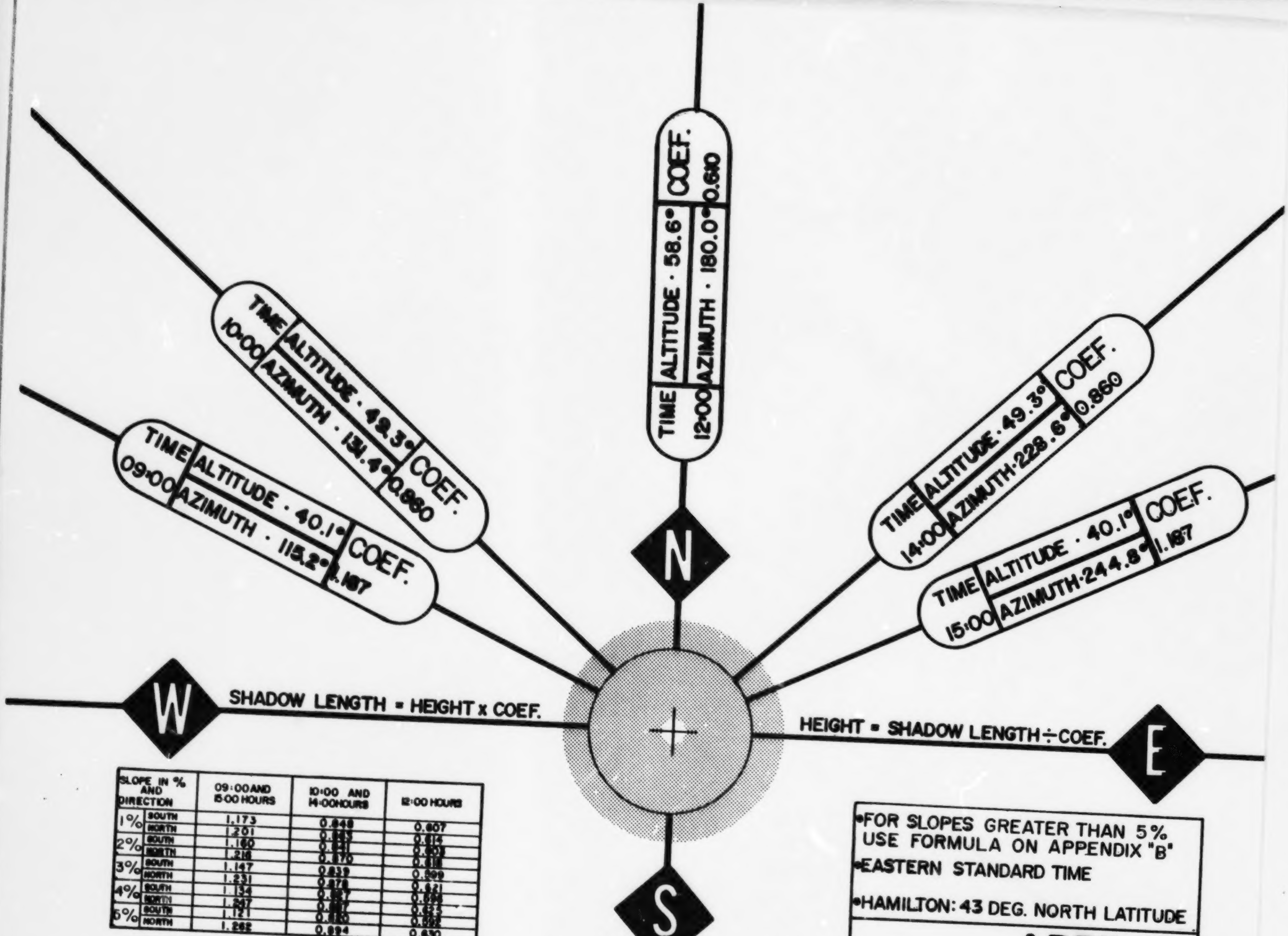
FEBRUARY 21



SLOPE IN % AND DIRECTION		09:00 AND 15:00 HOURS	10:00 AND 14:00 HOURS	12:00 HOURS
1%	SOUTH	1.630	1.207	0.924
	NORTH	1.686	1.237	0.941
2%	SOUTH	1.605	1.193	0.916
	NORTH	1.714	[illegible]	0.950
3%	SOUTH	1.579	1.179	0.907
	NORTH	1.744	[illegible]	0.958
4%	SOUTH	1.554	[illegible]	[illegible]
	NORTH	1.776	[illegible]	[illegible]
5%	SOUTH	1.530	[illegible]	[illegible]
	NORTH	1.807	1.301	0.979

- FOR SLOPES GREATER THAN 5 % USE FORMULA ON APPENDIX "B"
- EASTERN STANDARD TIME
- HAMILTON: 43 DEG. NORTH LATITUDE

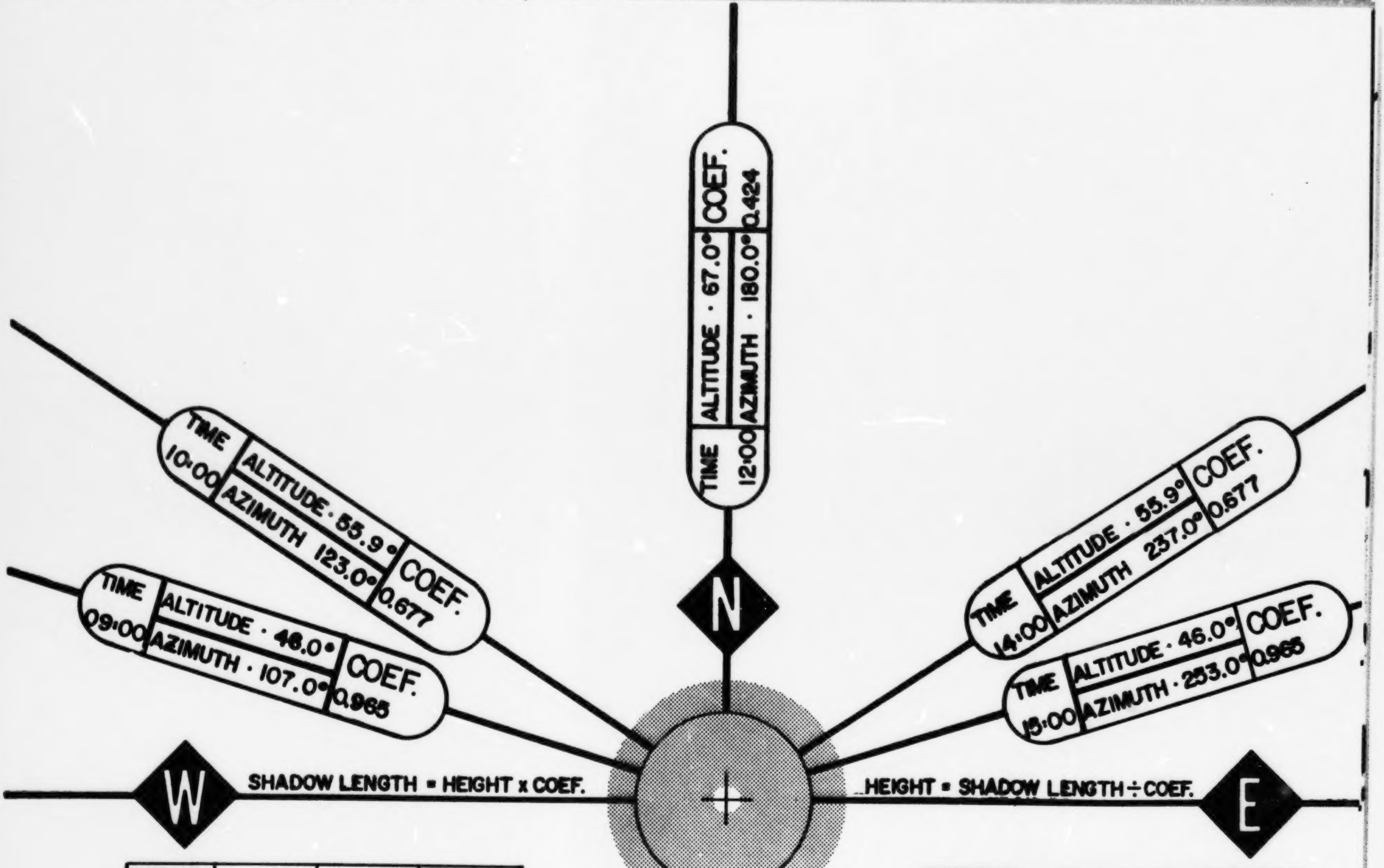
MARCH 21



SLOPE IN % AND DIRECTION		09:00 AND 15:00 HOURS	10:00 AND 14:00 HOURS	12:00 HOURS
1%	SOUTH	1.173	0.848	0.607
	NORTH	1.201	0.863	0.614
2%	SOUTH	1.160	[illegible]	0.603
	NORTH	1.216	0.870	0.618
3%	SOUTH	1.147	0.839	0.599
	NORTH	1.231	0.878	0.621
4%	SOUTH	1.134	0.827	0.596
	NORTH	1.247	0.887	0.623
5%	SOUTH	1.121	0.820	[illegible]
	NORTH	1.262	0.894	0.630

- FOR SLOPES GREATER THAN 5% USE FORMULA ON APPENDIX "B"
- EASTERN STANDARD TIME
- HAMILTON: 43 DEG. NORTH LATITUDE

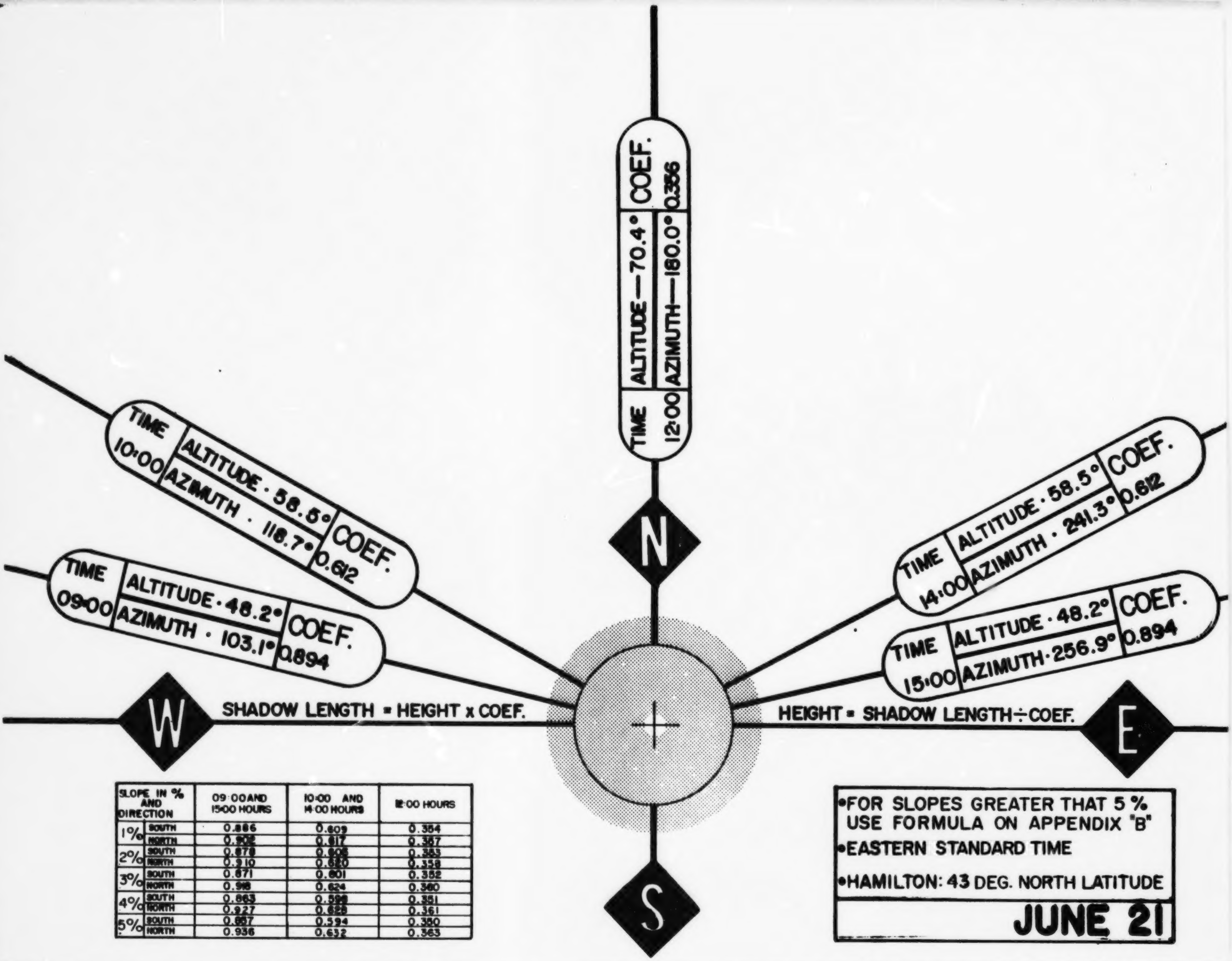
APRIL 21



SLOPE IN % AND DIRECTION		09:00 AND 15:00 HOURS	10:00 AND 14:00 HOURS	12:00 HOURS
1%	SOUTH	0.906	0.672	0.423
	NORTH	[illegible]	[illegible]	[illegible]
2%	SOUTH	[illegible]	[illegible]	0.421
	NORTH	[illegible]	[illegible]	[illegible]
3%	SOUTH	[illegible]	[illegible]	0.419
	NORTH	[illegible]	[illegible]	0.430
4%	SOUTH	[illegible]	[illegible]	0.417
	NORTH	1.004	[illegible]	0.432
5%	SOUTH	[illegible]	[illegible]	[illegible]
	NORTH	[illegible]	[illegible]	[illegible]

- FOR SLOPES GREATER THAN 5% USE FORMULA ON APPENDIX 'B'
- EASTERN STANDARD TIME
- HAMILTON: 43 DEG. NORTH LATITUDE

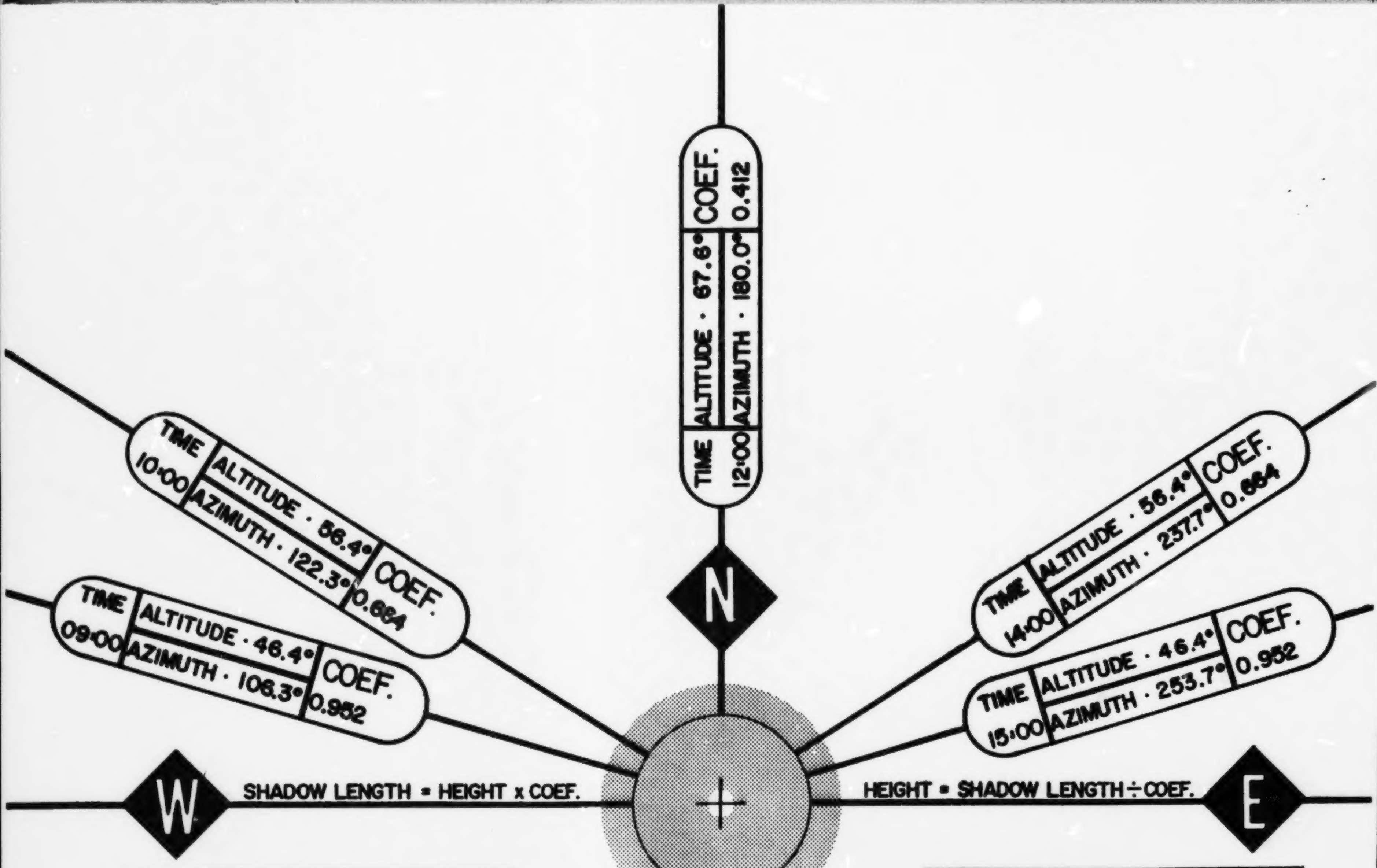
MAY 21



SLOPE IN % AND DIRECTION		09:00 AND 15:00 HOURS	10:00 AND 14:00 HOURS	12:00 HOURS
1%	SOUTH	0.886	0.609	0.354
	NORTH	0.902	0.617	0.357
2%	SOUTH	0.878	0.605	0.353
	NORTH	0.910	0.620	0.358
3%	SOUTH	0.871	0.601	0.352
	NORTH	0.918	0.624	0.360
4%	SOUTH	0.863	0.598	0.351
	NORTH	0.927	0.628	0.361
5%	SOUTH	0.857	0.594	0.350
	NORTH	0.936	0.632	0.363

- FOR SLOPES GREATER THAT 5 % USE FORMULA ON APPENDIX "B"
- EASTERN STANDARD TIME
- HAMILTON: 43 DEG. NORTH LATITUDE

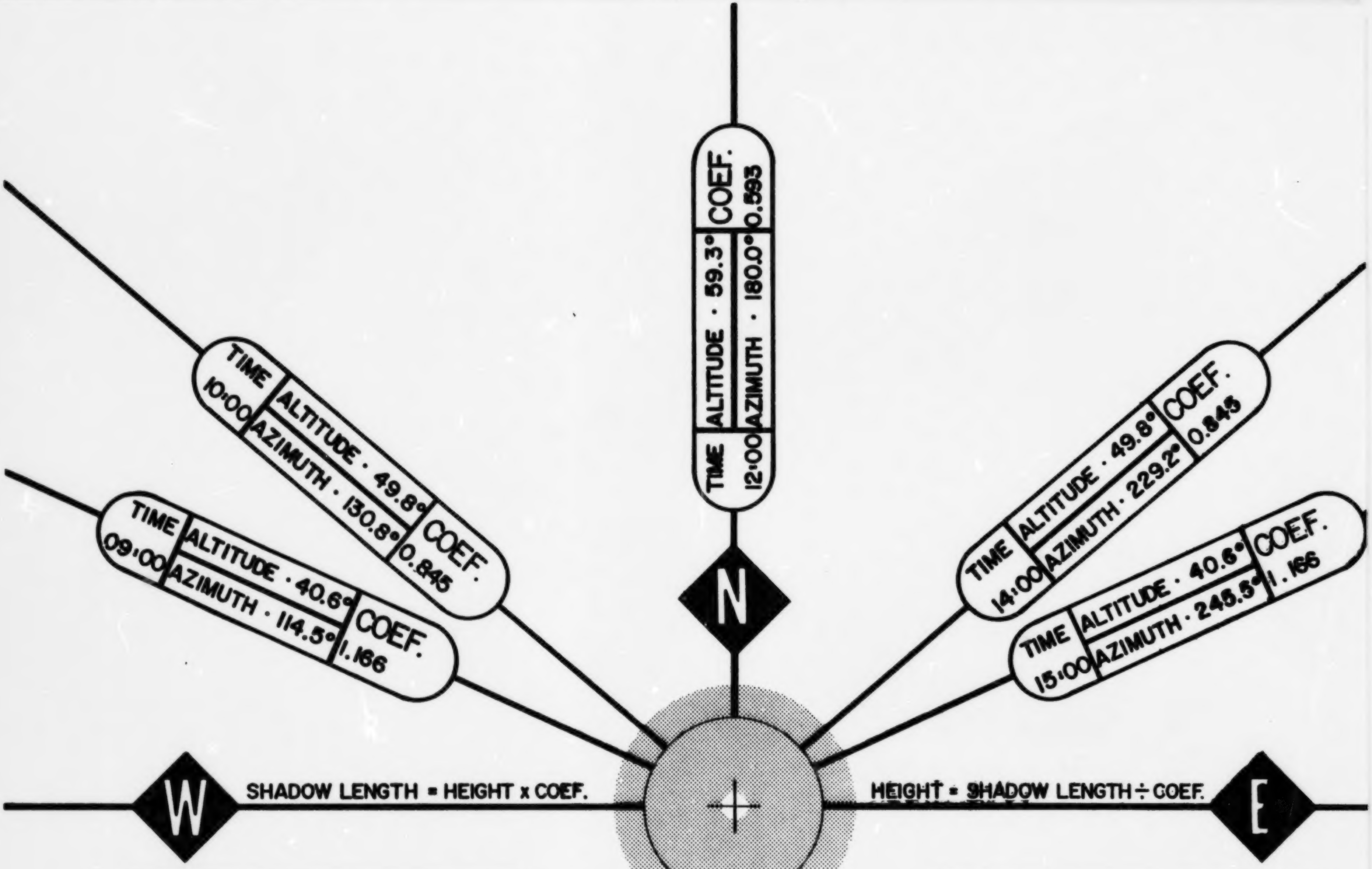
JUNE 21



SLOPE IN % AND DIRECTION		09·00 AND 15·00 HOURS	10:00 AND 14:00 HOURS	12:00 HOURS
1%	SOUTH	0.944	[illegible]	0.410
	NORTH	0.96	[illegible]	0.414
2%	SOUTH	0.935	[illegible]	0.409
	NORTH	0.971	[illegible]	0.416
3%	SOUTH	0.925	[illegible]	0.407
	NORTH	0.980	0.677	0.417
4%	SOUTH	0.917	[illegible]	0.405
	NORTH	0.990	[illegible]	0.419
5%	SOUTH	0.909	[illegible]	0.404
	NORTH	0.999	0.687	0.421

- FOR SLOPES GREATER THAN 5% USE FORMULA ON APPENDIX 'B'
- EASTERN STANDARD TIME
- HAMILTON: 43 DEG. NORTH LATITUDE

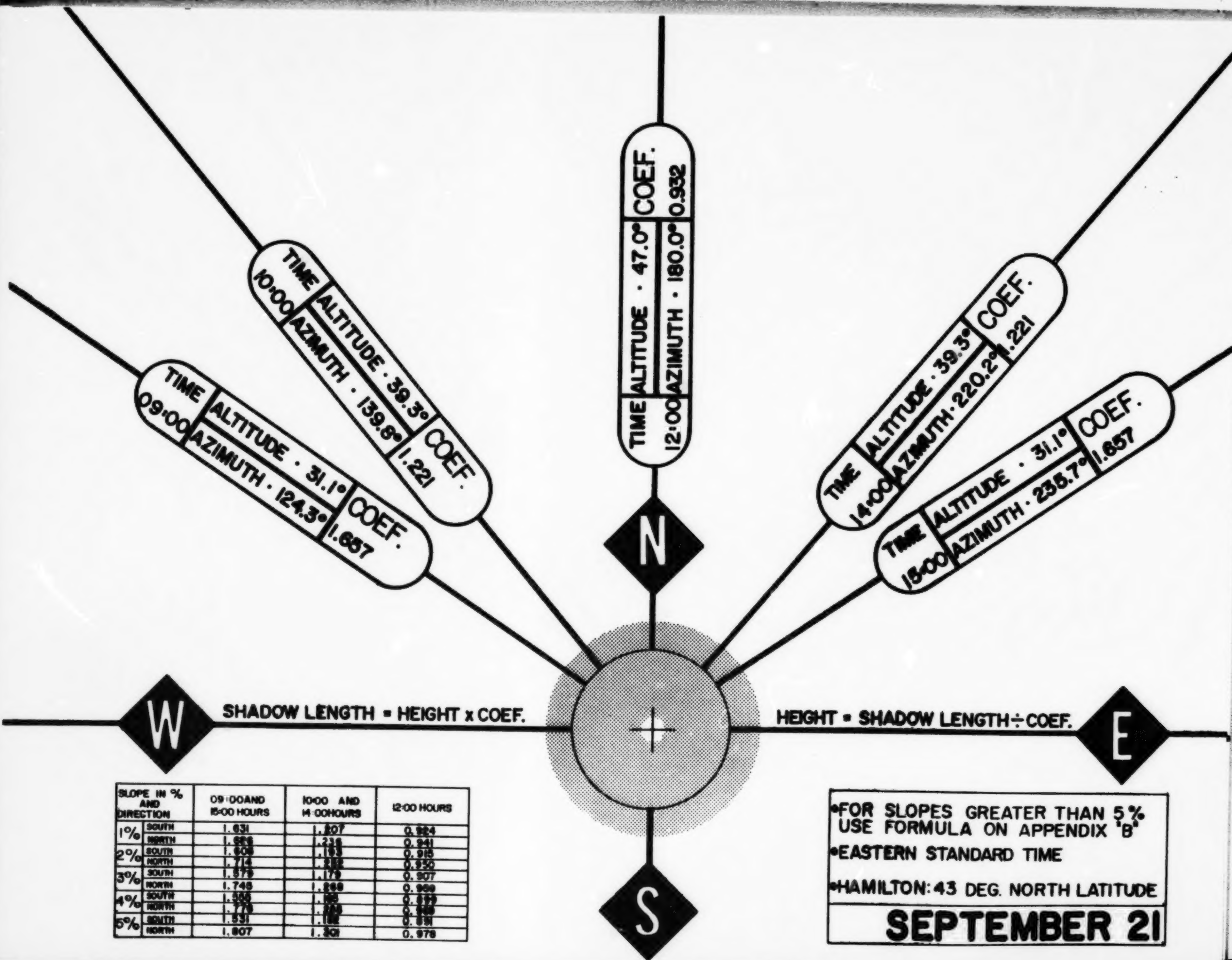
JULY 21



SLOPE IN % AND DIRECTION		09:00 AND 15:00 HOURS	10:00 AND 14:00 HOURS	12:00 HOURS
1%	SOUTH	1.153	0.838	0.590
	NORTH	1.180	0.852	0.597
2%	SOUTH	1.140	0.831	0.587
	NORTH	1.194	[illegible]	0.601
3%	SOUTH	1.127	0.824	0.583
	NORTH	1.209	0.867	0.605
4%	SOUTH	1.115	0.817	0.580
	NORTH	1.224	0.878	0.608
5%	SOUTH	1.102	0.811	0.573
	NORTH	1.239	0.882	0.612

- FOR SLOPS GREATER THAN 5 % USE FORMULA ON APPENDIX "B"
- EASTERN STANDARD TIME
- HAMILTON: 43 DEG. NORTH LATITUDE

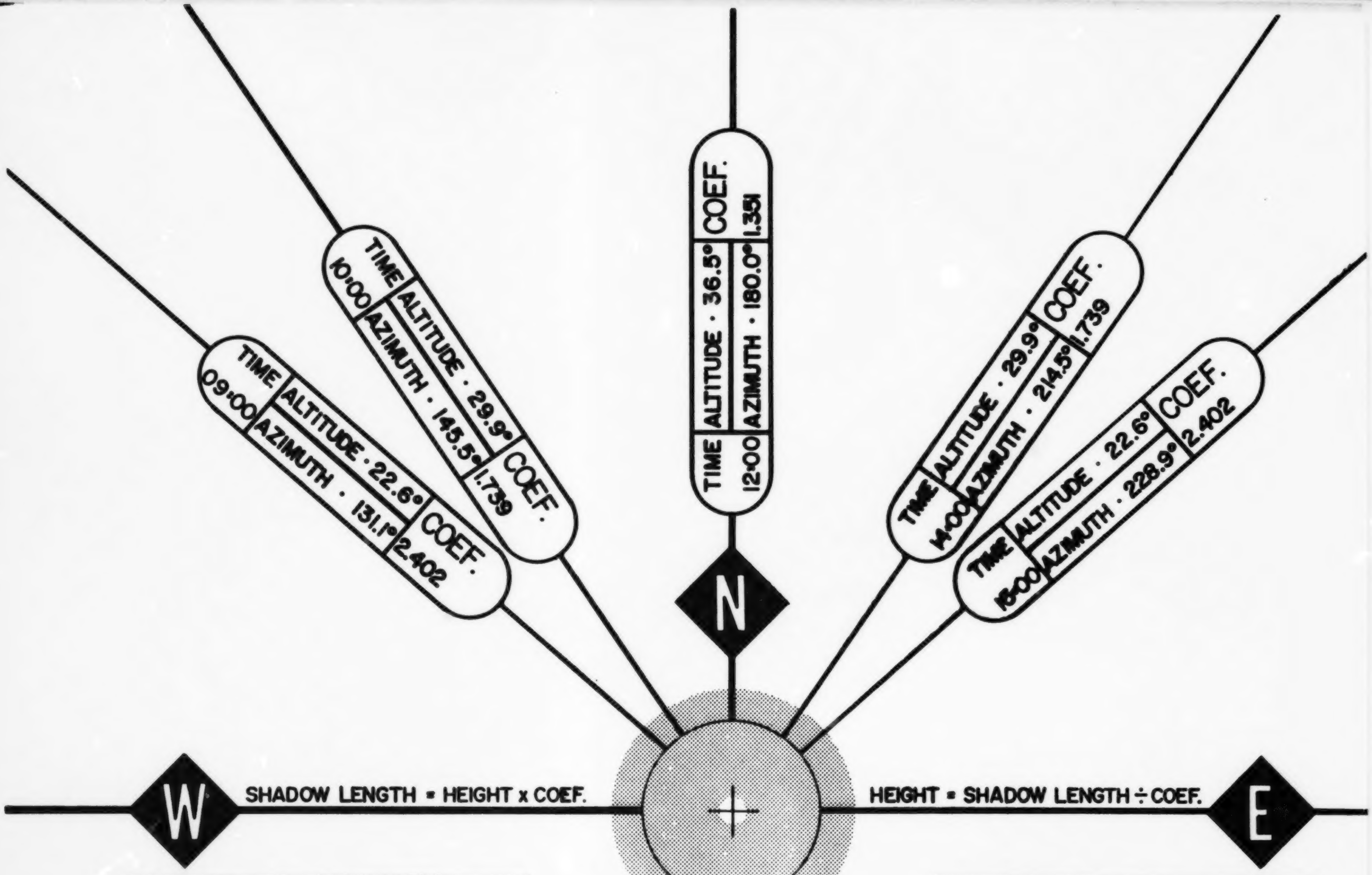
AUGUST 21



SLOPE IN % AND DIRECTION		09:00 AND 15:00 HOURS	10:00 AND 14:00 HOURS	12:00 HOURS
1%	SOUTH	1.631	1.207	0.924
	NORTH	[illegible]	1.236	0.941
2%	SOUTH	[illegible]	1.193	0.915
	NORTH	1.714	[illegible]	0.950
3%	SOUTH	[illegible]	1.179	0.907
	NORTH	1.748	[illegible]	[illegible]
4%	SOUTH	[illegible]	[illegible]	[illegible]
	NORTH	[illegible]	[illegible]	[illegible]
5%	SOUTH	1.531	[illegible]	[illegible]
	NORTH	1.807	1.301	0.978

- FOR SLOPES GREATER THAN 5% USE FORMULA ON APPENDIX 'B'
- EASTERN STANDARD TIME
- HAMILTON: 43 DEG. NORTH LATITUDE

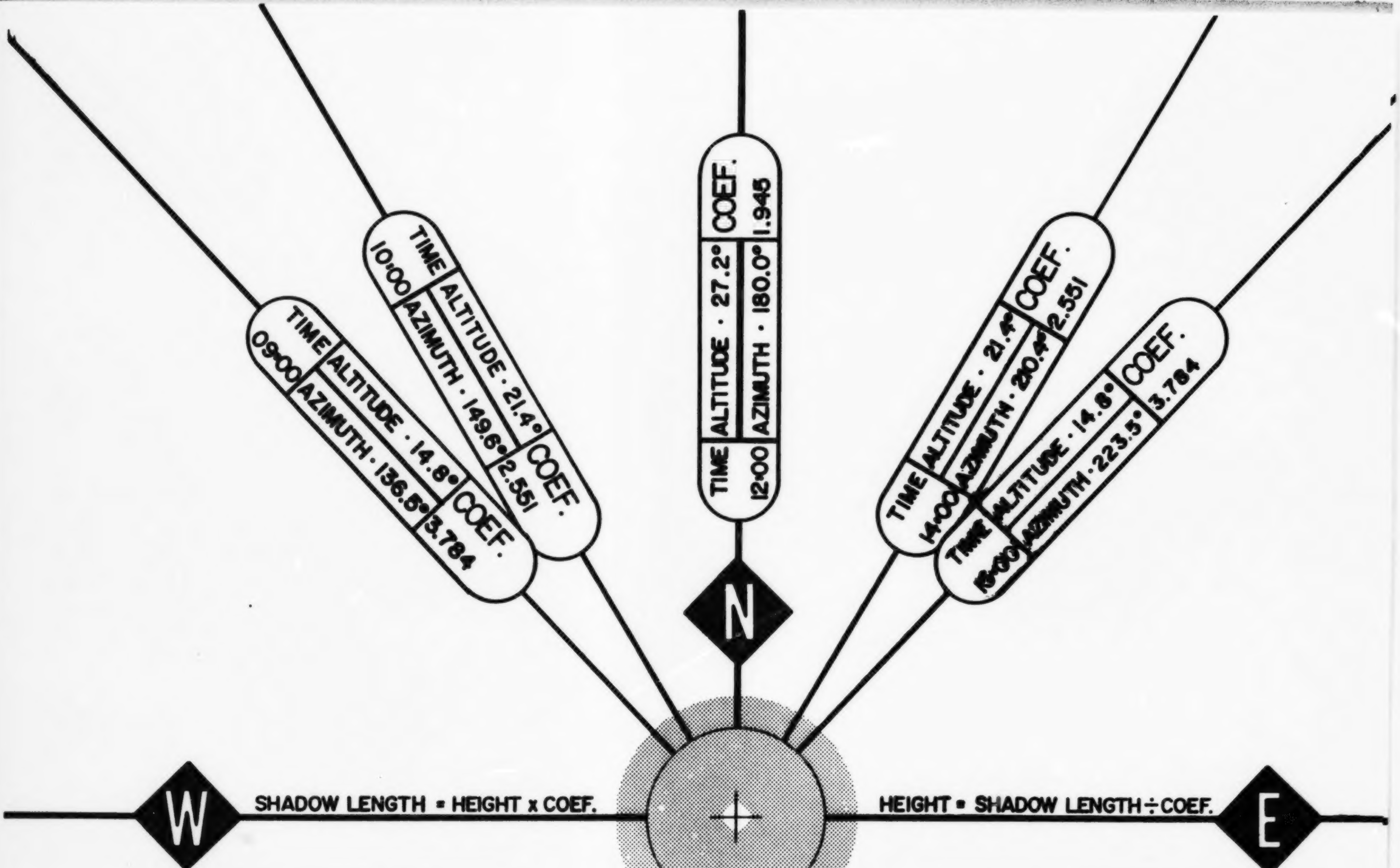
SEPTEMBER 21



SLOPE IN % AND DIRECTION		09:00AND 15 00 HOURS	10:00 AND 14:00HOURS	12 00 HOURS
1%	SOUTH	2.346	1.709	1.333
	NORTH	2.461	1.769	1.370
2%	SOUTH	2.292	1.681	1.315
	NORTH	2.523	1.802	1.389
3%	SOUTH	2.241	1.646	1.298
	NORTH	2.589	1.835	1.409
4%	SOUTH	2.192	1.634	1.282
	NORTH	2.658	1.869	1.427
5%	SOUTH	2.145	1.600	1.266
	NORTH	2.730	1.904	1.449

- FOR SLOPES GREATER THAN 5 % USE FORMULA ON APPENDIX "B"
- EASTERN STANDARD TIME
- HAMILTON: 43 DEG. NORTH LATITUDE

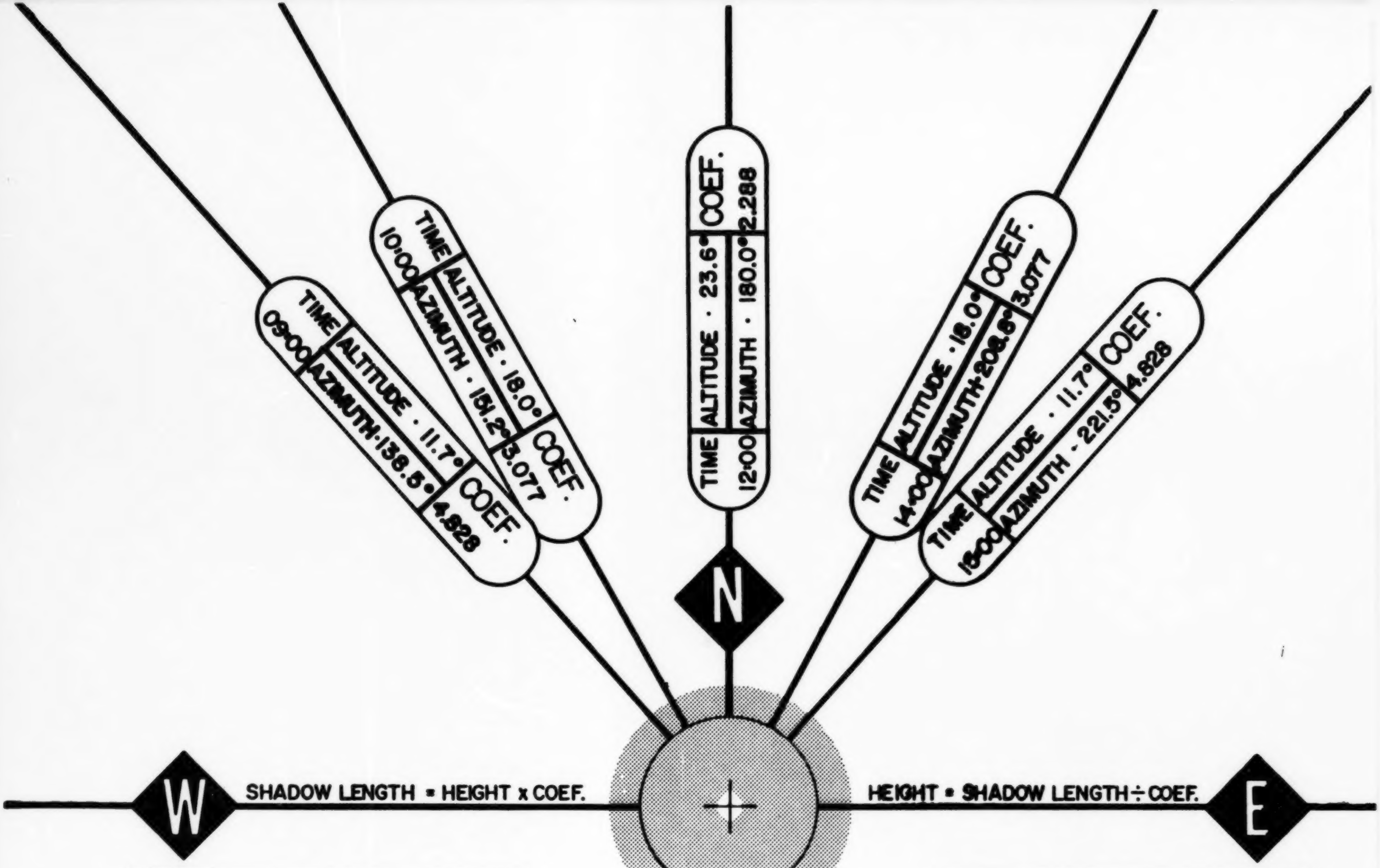
OCTOBER 21



SLOPE IN % AND DIRECTION		09:00 AND 15:00 HOURS	10:00 AND 14:00 HOURS	12:00 HOURS
1%	SOUTH	3.647	2.551	1.909
	NORTH	3.934	2.619	1.984
2%	SOUTH	3.619	2.428	1.873
	NORTH	4.094	2.488	2.024
3%	SOUTH	3.399	2.370	1.838
	NORTH	4.270	2.763	2.066
4%	SOUTH	3.267	2.318	1.806
	NORTH	4.599	2.842	2.110
5%	SOUTH	3.183	2.262	1.773
	NORTH	4.668	2.925	2.156

- FOR SLOPS GREATER THAN 5% USE FORMULA ON APPENDIX "B"
- EASTERN STANDARD TIME
- HAMILTON: 43 DEG. NORTH LATITUDE

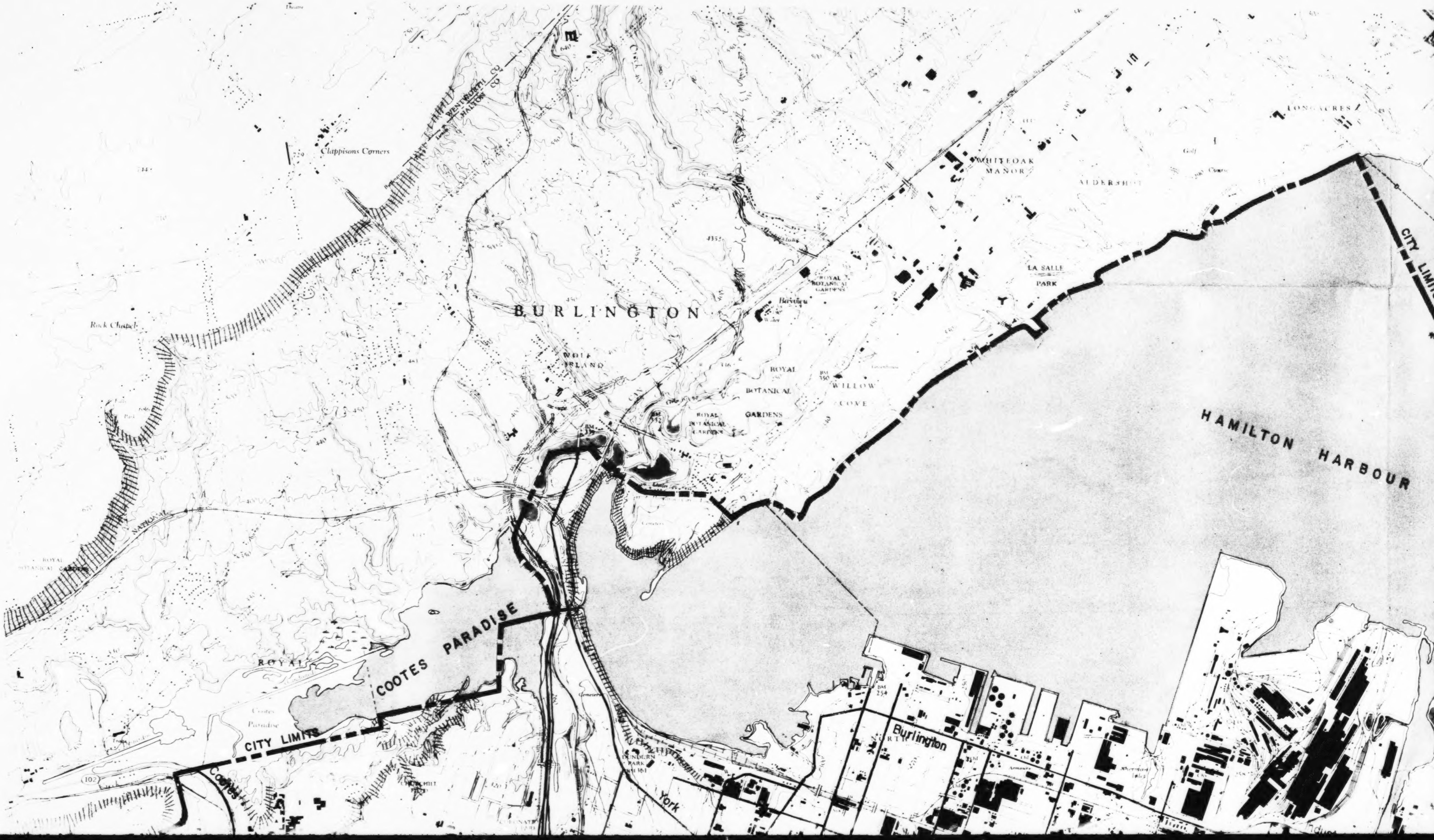
NOVEMBER 21



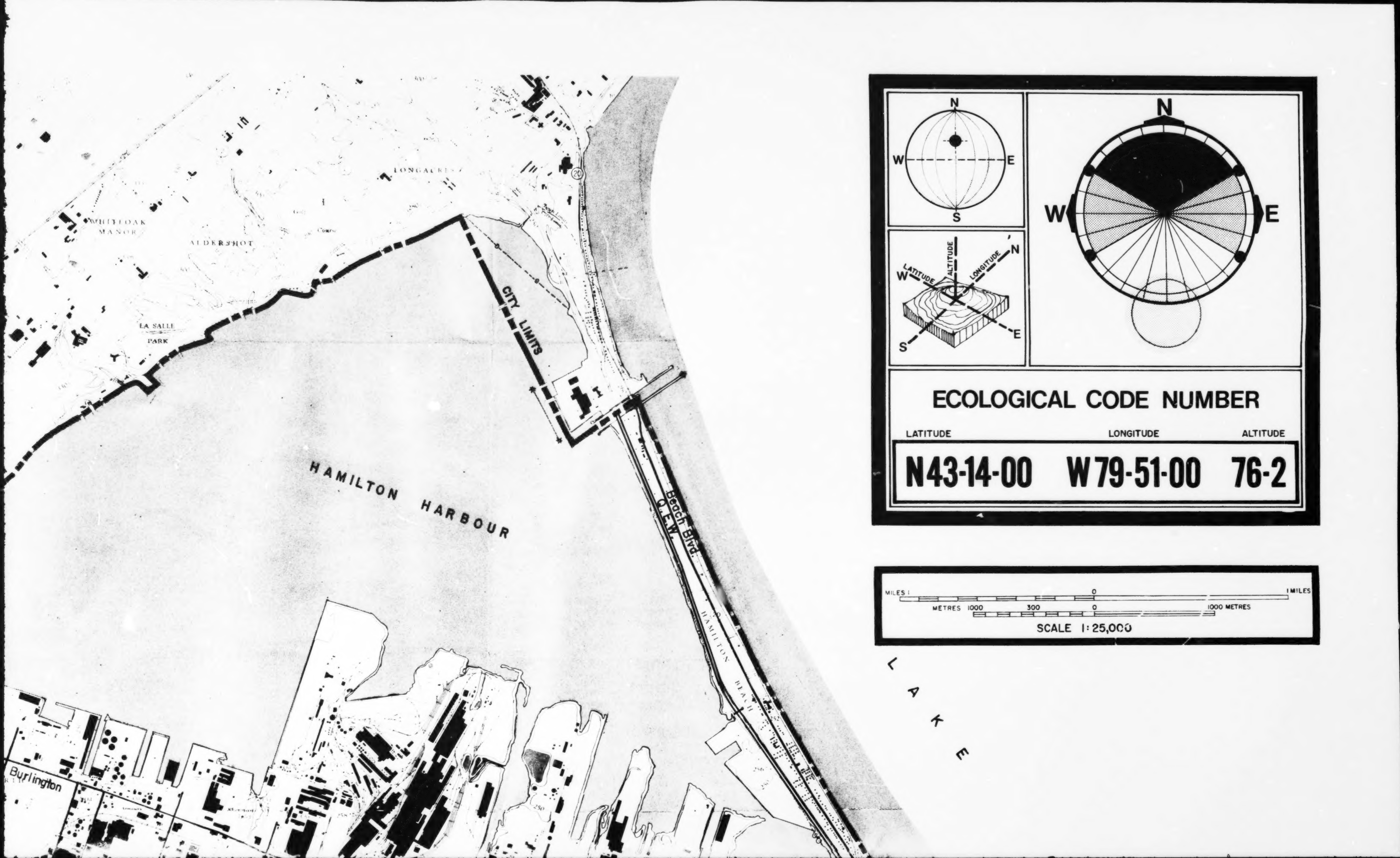
SLOPE IN % AND DIRECTION		09:00 AND 15:00 HOURS	10:00 AND 14:00 HOURS	12:00 HOURS
1%	SOUTH	4.607	2.986	2.238
	NORTH	5.014	3.178	2.342
2%	SOUTH	4.404	2.900	2.189
	NORTH	5.344	3.280	2.393
3%	SOUTH	4.218	2.818	2.142
	NORTH	5.647	3.392	2.468
4%	SOUTH	4.047	2.741	2.097
	NORTH	5.985	3.511	2.520
5%	SOUTH	3.890	2.669	2.054
	NORTH	6.365	3.638	2.584

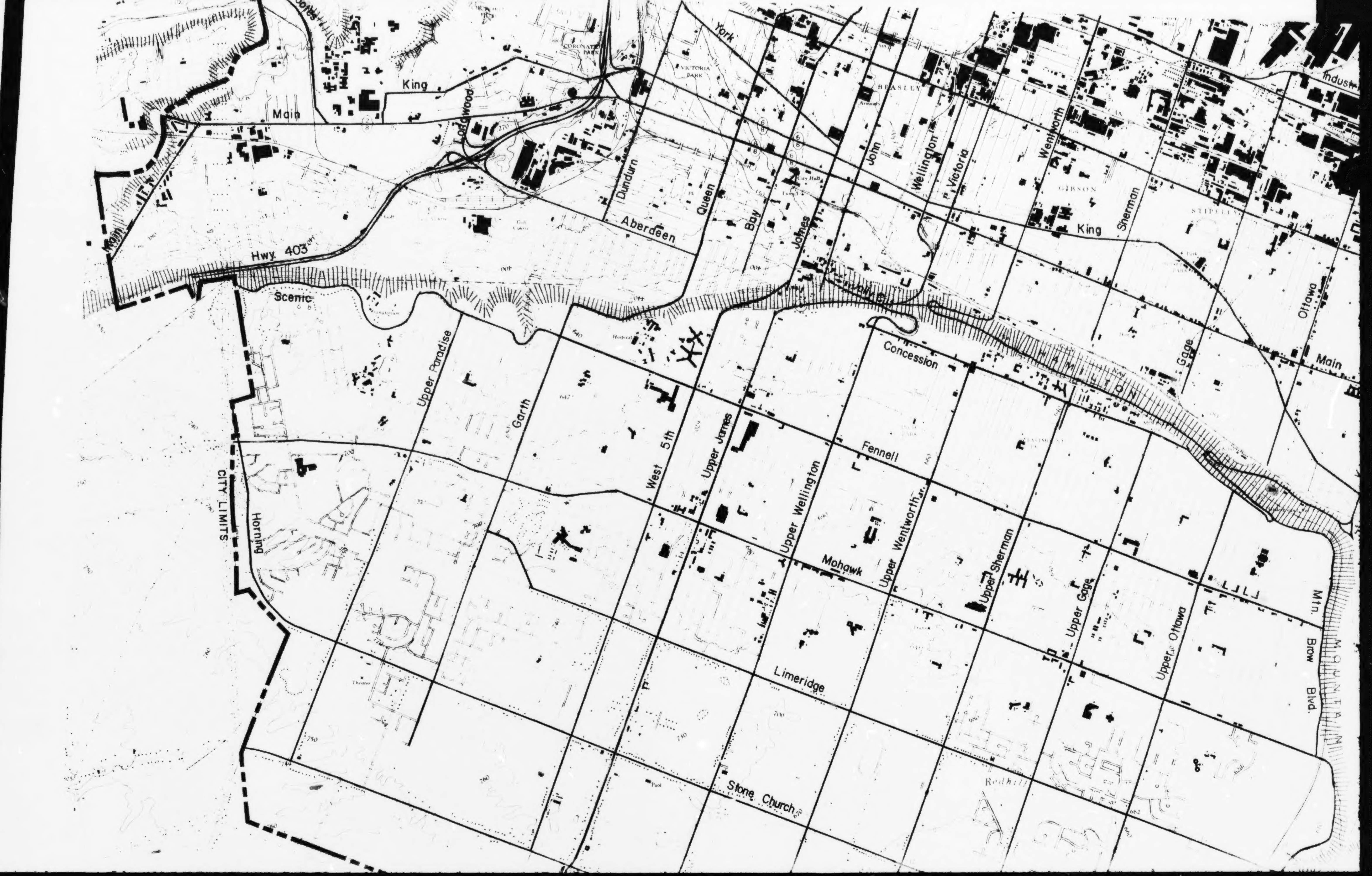
- FOR SLOPES GREATER THAN 5 % USE FORMULA ON APPENDIX "B"
- EASTERN STANDARD TIME
- HAMILTON: 43 DEG. NORTH LATITUDE

DECEMBER 21



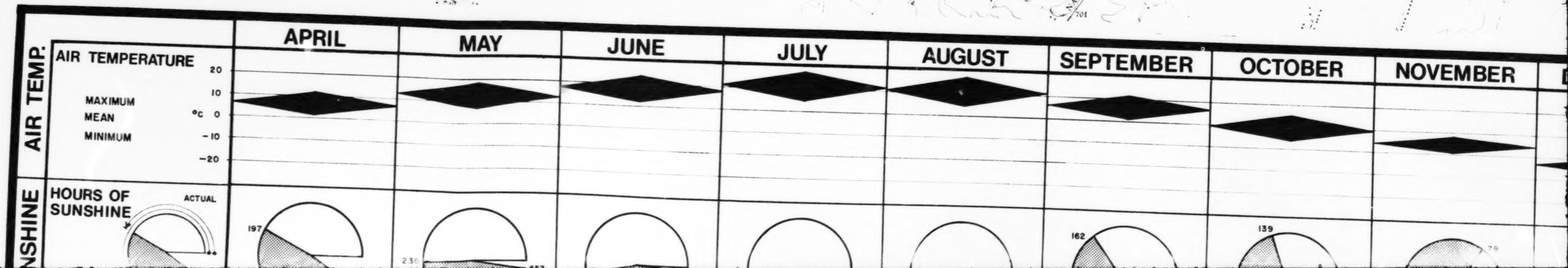
Clappisons Corners
Rock Chapel
BURLINGTON
WHITEOAK MANOR
ALDERSHOT
LONGACRES
Golf Course
LA SALLE PARK
ROYAL BOTANICAL GARDENS
ROYAL BOTANICAL GARDENS
WILLOW COVE
HAMILTON HARBOUR
CITY LIMITS
CITY LIMITS
COOTES PARADISE
Cootes Paradise
ROYAL
NATIONAL
DUNDURN PARK
Burlington
York

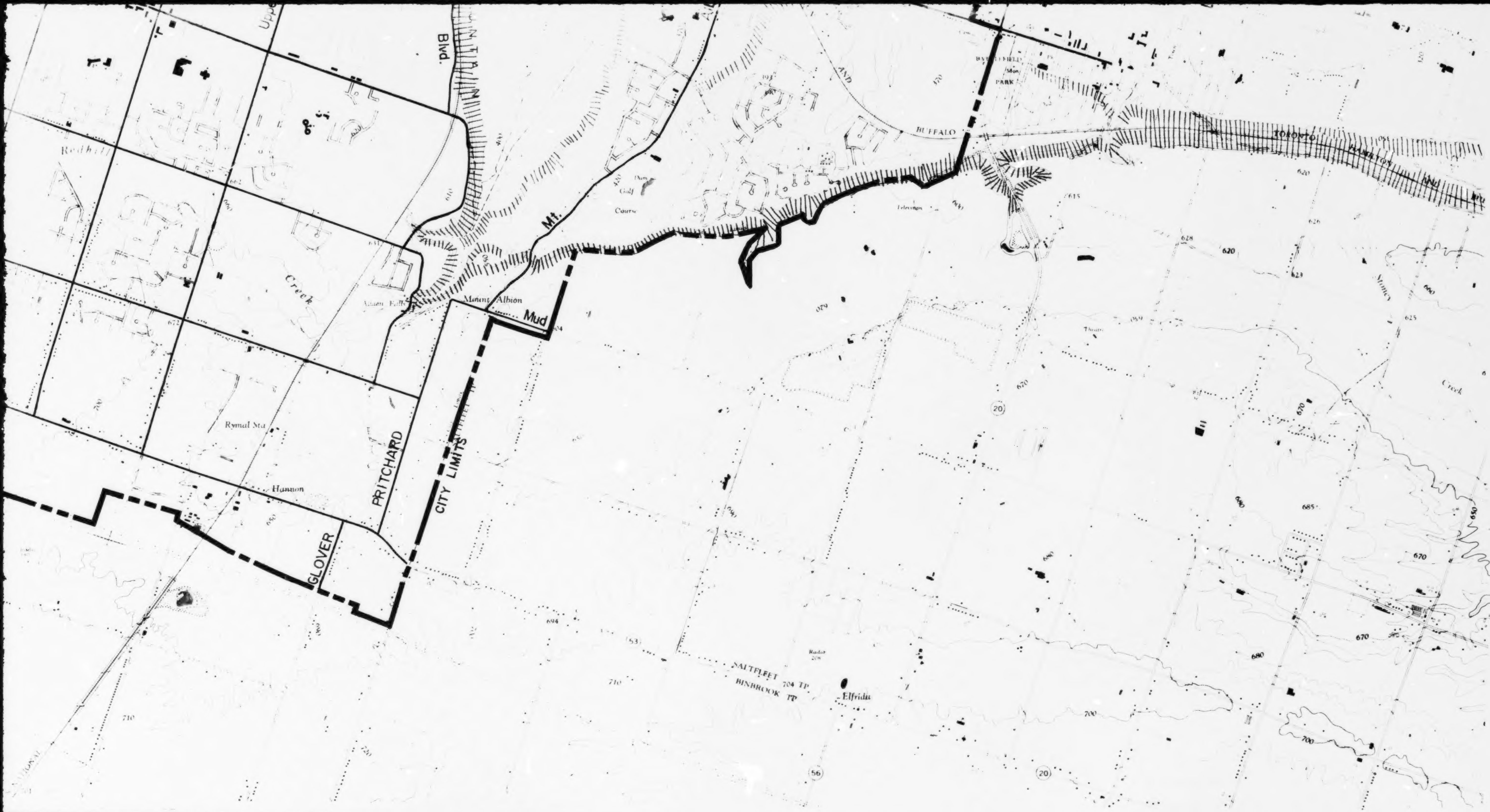

WHITEOAK MANOR
ALDERSHOT
LA SALLE PARK
CITY LIMITS
HAMILTON HARBOUR
Beach Blvd.
Q.E.W.
HAMILTON BEACH
Burlington
LAKE
N
S
W
E
LATITUDE
ALTITUDE
LONGITUDE
ECOLOGICAL CODE NUMBER
LATITUDE LONGITUDE ALTITUDE
N43-14-00 W79-51-00 76-2
MILES 1 0 1 MILES
METRES 1000 300 0 1000 METRES
SCALE 1:25,000


York
King
Main
Dundurn
Queen
Bay
James
John
Wellington
Victoria
Wentworth
Sherman
King
Aberdeen
Hwy. 403
Scenic
Upper Paradise
Garth
West 5th
Upper James
Upper Wellington
Upper Wentworth
Upper Sherman
Upper Gage
Upper Ottawa
Concession
Fennell
Mohawk
Limeridge
Stone Church
Gage
Ottawa
Main
CITY LIMITS
Horning
Mtn. Brow Blvd.
HAMILTON
Redhill

ONTARIO
Industrial
Wentworth
Sherman
King
Barton
Ottawa
Main
Gage
HAMILTON
Strathearn
Parkdale
Woodward
Kenilworth
Queenston
Q.E.W.
Lake
Grays
Parkway
Centennial
Pottruff
Nash
King
Albion
Cochrane
Upper Sherman
Upper Gage
Upper Ottawa
Mtn. Brow Blvd.

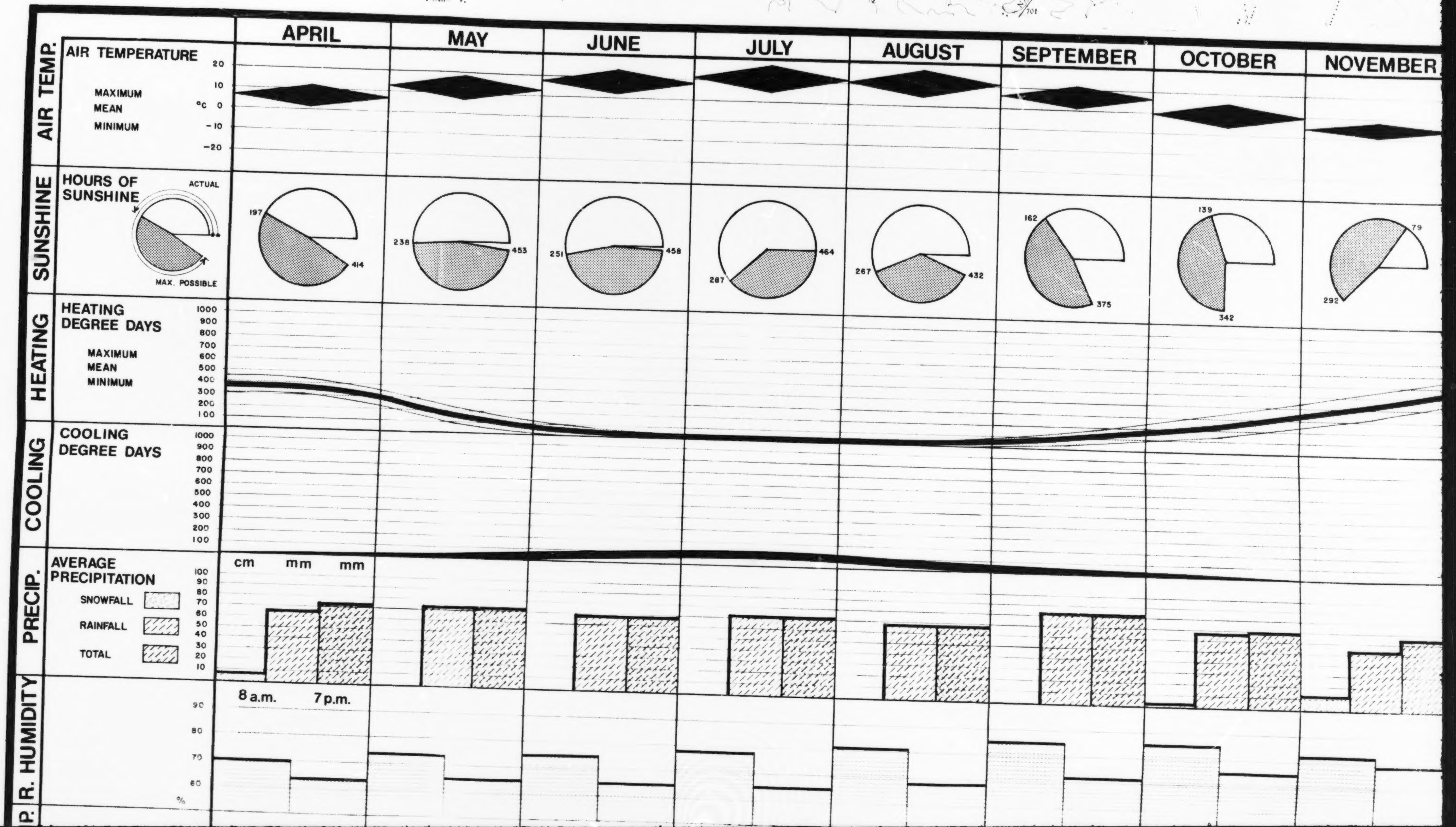
Limeridge
Blvd.
Stone Church
Redhill
Rymal
(Hwy. 53)
CITY LIMITS
MILES
Creek
Rymal Sta
Hannon
PRITCHARD
GLOVER
CITY LIMITS
Twenty
North Glanford
ANCASTER TP
NATIONAL
HAMILTON
AIRPORT


AIR TEMP.
AIR TEMPERATURE
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
20
10
MAXIMUM
MEAN
°C 0
MINIMUM
-10
-20
SUNSHINE
HOURS OF SUNSHINE
ACTUAL
197
162
139

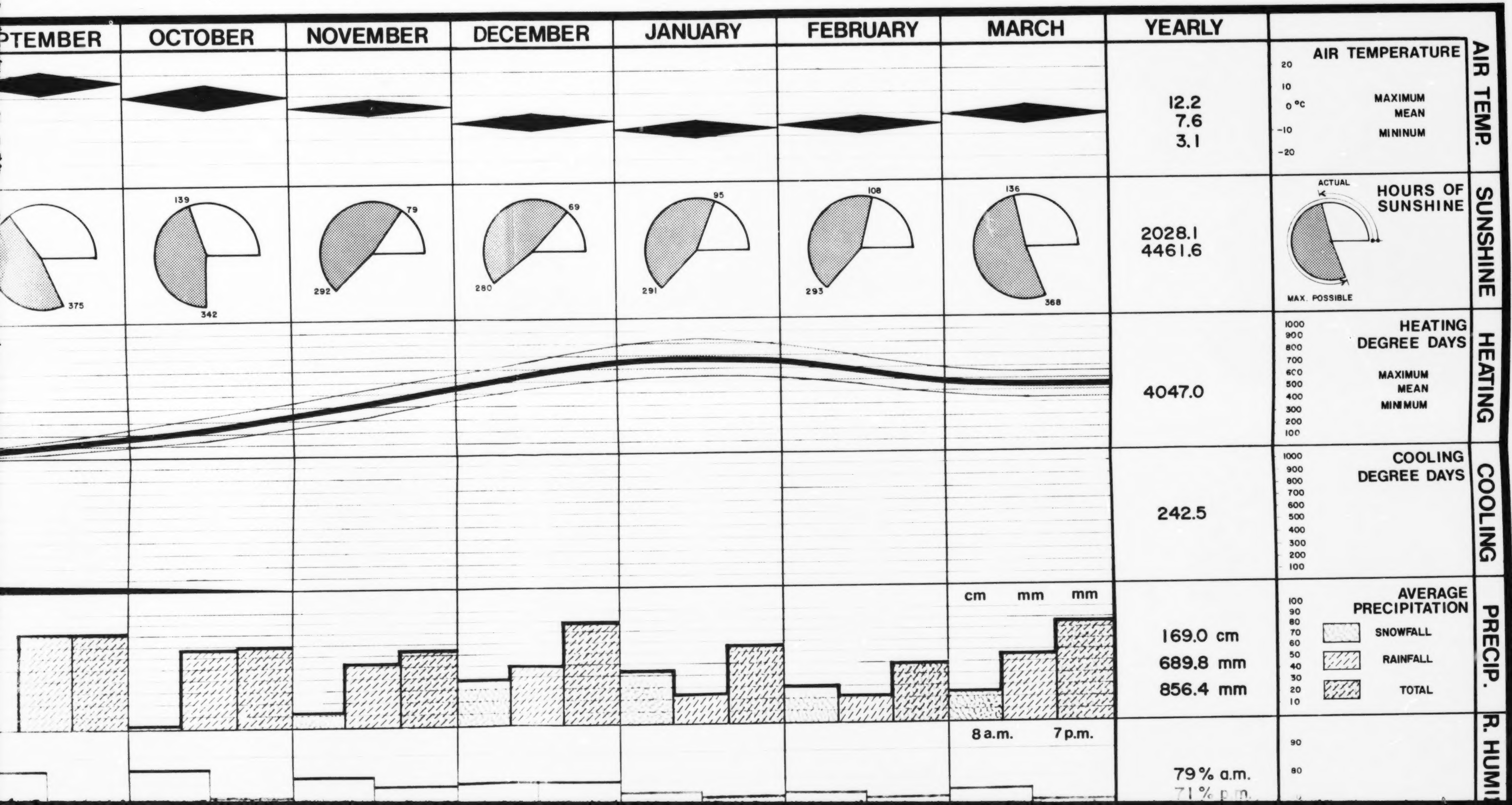


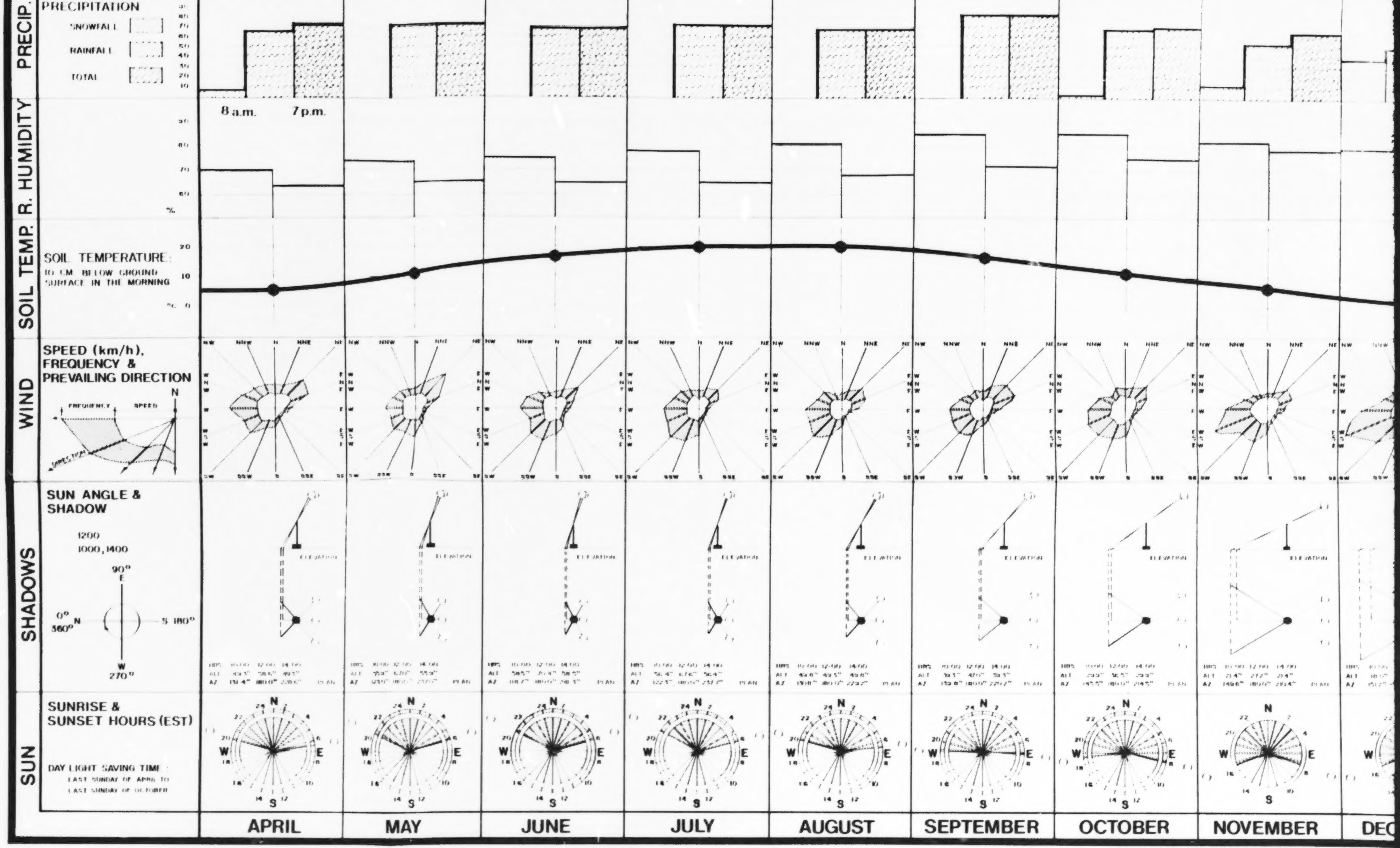
SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	JANUARY	FEBRUARY	MARCH	YEARLY		
							12.2 7.6 3.1	AIR TEMPERATURE 20 10 0 °C MAXIMUM MEAN -10 MININUM -20	AIR TEMP.
	139	79	59	95	108	136		ACTUAL HOURS OF	S

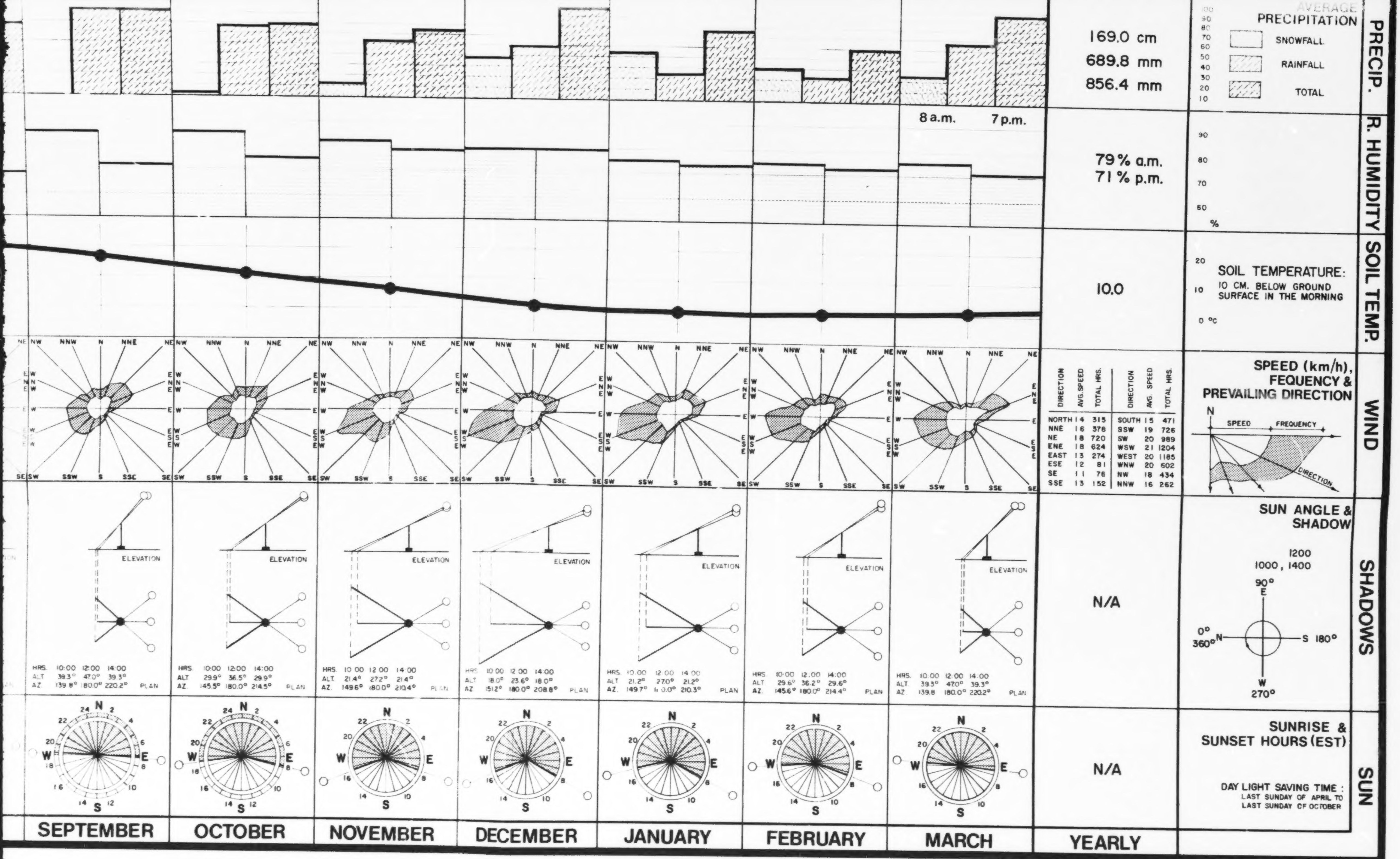
HAMILTON
AIRPORT
Three
Twenty
Creek
NATIONAL
766
774
750
710
700
695
701
747


APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER
AIR TEMP.
AIR TEMPERATURE
MAXIMUM
MEAN
MINIMUM
°C
20
10
0
−10
−20
SUNSHINE
HOURS OF SUNSHINE
ACTUAL
MAX. POSSIBLE
197
414
238
453
251
458
287
464
267
432
162
375
139
342
79
292
HEATING
HEATING DEGREE DAYS
MAXIMUM
MEAN
MINIMUM
1000
900
800
700
600
500
400
300
200
100
COOLING
COOLING DEGREE DAYS
1000
900
800
700
600
500
400
300
200
100
PRECIP.
AVERAGE PRECIPITATION
SNOWFALL
RAINFALL
TOTAL
cm
mm
mm
100
90
80
70
60
50
40
30
20
10
R. HUMIDITY
8 a.m.
7 p.m.
90
80
70
60
%
P.

SALTFLEET TP
BINBROOK TP
Elfrida
Radio
704
694
710
720
700
680
670
53
56
20


PTEMBER
OCTOBER
NOVEMBER
DECEMBER
JANUARY
FEBRUARY
MARCH
YEARLY
12.2
7.6
3.1
AIR TEMPERATURE
20
10
0 °C
-10
-20
MAXIMUM
MEAN
MININUM
AIR TEMP.
139
79
69
95
108
136
375
342
292
280
291
293
368
2028.1
4461.6
ACTUAL
HOURS OF SUNSHINE
MAX. POSSIBLE
SUNSHINE
4047.0
1000
900
800
700
600
500
400
300
200
100
HEATING DEGREE DAYS
MAXIMUM
MEAN
MINIMUM
HEATING
242.5
COOLING DEGREE DAYS
COOLING
cm
mm
mm
169.0 cm
689.8 mm
856.4 mm
90
80
70
60
50
40
30
20
10
AVERAGE PRECIPITATION
SNOWFALL
RAINFALL
TOTAL
PRECIP.
8 a.m.
7 p.m.
79% a.m.
71% p.m.
R. HUMI


PRECIP.
PRECIPITATION
SNOWFALL
RAINFALL
TOTAL
R. HUMIDITY
8 a.m.
7 p.m.
%
SOIL TEMP.
SOIL TEMPERATURE:
10 CM. BELOW GROUND SURFACE IN THE MORNING
WIND
SPEED (km/h), FREQUENCY & PREVAILING DIRECTION
FREQUENCY
SPEED
N
SHADOWS
SUN ANGLE & SHADOW
1200
1000, 1400
90°
E
0°
360° N
S 180°
W
270°
ELEVATION
PLAN
SUN
SUNRISE & SUNSET HOURS (EST)
DAY LIGHT SAVING TIME:
LAST SUNDAY OF APRIL TO
LAST SUNDAY OF OCTOBER
N
S
E
W
APRIL
MAY
JUNE
JULY
AUGUST
SEPTEMBER
OCTOBER
NOVEMBER



FOR FURTHER INFORMATION SEE APPENDICES

ECOCHART OF HAMILTON